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Water Supplies

Until comparatively recent times the imagination of man did not rise beyond calling upon the water diviner or the well-digger when the perennial problem of obtaining improved water supplies became a major necessity of life. Such simple faith no longer serves. To-day the realization of the great complexity of the hydrologic cycle as it affects man, and the land he attempts to exploit, has led to the recent formation of such bodies as the Water Planning Committee of the National Resources Board in the United States of America, and the Inland Water Survey in the United Kingdom, to investigate and report on this vital subject of which the world is still comparatively ignorant. The formation of a similar body for East Africa will no doubt come about in time.

In Africa as a whole the most fundamental factor influencing settlement is probably rainfall, and with it water supply, but owing to the comparatively short period over which records have been kept and the paucity of recording stations, knowledge has usually had to be replaced by intelligent guesswork when forming an estimate of the water supply of a region and its suitability for a particular crop. In time the work of the recently formed British East African Meteorological Service, linked with that of the soil chemist, the ecologist, and the aerial surveyor, will remedy this state of

affairs and provide us with those data without which it is impossible to assess, or manage, our available water supplies. For in agriculture we need to know more than the mere mean annual rainfall figures of a district, when assessing its agricultural possibilities. We also want to know its distribution, intensity, and reliability. In addition, for a true understanding of the available underground water supply we must have a fairly accurate knowledge of the run-off, the absorption by the soil and the loss from evaporation. For instance, as a crop of maize is said to transpire from its leaves and stems the equivalent of five inches of rainfall during its growing period, it is obviously important to know what proportion of a total rainfall, of say 30 inches, can be expected within that period and what proportion is lost by run-off and evaporation from the soil. Unfortunately, such data are practically non-existent for most of Africa.

In East Africa the water problem, more especially in native areas, is largely one of domestic supply, as can be seen from the fact that large areas of the country are almost devoid of population, even though the rainfall is sufficient to grow suitably chosen food crops in average seasons. Because of this it might be supposed that the solution to the water problem would be found comparatively simply by the construction of storage basins; but past experience with this method is not encouraging and points to the fact that such stores, whether in the form of large dams or village tanks, all suffer from the same faults, namely excessive evaporation and silting. For this reason reliance must largely be placed on intelligent exploitation of the underground supplies.

In an article which we publish in this issue Mr. C. Gillman, the Water Consultant to the Government of Tanganyika Territory, gives an illuminating description of the complexity of this subject of water supply as it affects East Africa, and points out the urgent necessity for research into the whole subject of our hydrological conditions before we shall have the knowledge necessary to "keep our house in order." Nor should it be thought that East Africa is alone in its lack of knowledge on this subject; similar gaps are evident everywhere. Are we sure, for instance, that a satisfactory explanation has been found for the formation of those mysterious water supplies, the dew ponds on the tops of the chalk downs in southern England?

In the article referred to, Mr. Gillman first of all introduces us to the hydrologic cycle in its simplest form so that one reads on, feeling that the subject is comparatively straightforward. What could be plainer than the formula: precipitation equals run-off plus evaporation plus transpiration plus absorption? But as the reader progresses he finds that it is not so simple as he thought and that he is being led by Mr. Gillman into a labyrinth of difficult problems such as he never dreamed of before and the solution of which is likely to occupy trained brains for many a year. As illustrations of the complexity of the subject as it affects East Africa, consider the following problems, to mention only a few of many:

Is grassland a better preserver of the underground water supply than woodland? Certain evidence points to the fact that it may be.

Taking into account the effect of annual fires, with consequent increased run-off and possible soil erosion, how would the water supply be affected by large-scale replacement of woodland by grass?

Is a forest cover in the mountains the best way to regularize the water supply

of East Africa? Recent work in the U.S.A. rather indicates that there other forms of vegetation may be more effective.

Does the fringing forest beside streams use up more water by transpiration than it protects from evaporation?

All these questions and many others must be answered by careful research before we can pretend to know anything about our water supplies, and such research must be the work of many years. The preservation and proper utilization of the limited permanent water supplies of the country should be our aim.

Readers who are interested in this subject of water supplies may care for references to past numbers of this Journal which contain pertinent articles or notes on this subject, namely: September, 1935, July, September and November, 1936, and September, 1937.

A. G. H.

Current Notes

Compost with chemical starters

The shortage of cattle manure in certain districts of the Bombay Presidency has led to experiments with chemical starters. It has been found that ammonium sulphate with calcium carbonate acts very effectively. With leafy material from the local forests the economic dose is 0.3 per cent nitrogen as ammonium sulphate and 5 per cent calcium carbonate. The organic material must be well mixed with a suspension of these two starters and heaped above ground under shade. The heap must be raked and watered at intervals of eight to ten days. Aeration must be good and moisture content should be maintained at sixty to seventy per cent. Provided these precautions are carefully carried out, the fermentation will be complete in about ninety days and the manure will be ready for application to the soil. The cost of manure by this method is not much greater than that by the cultivator's method.

Though it is not cheaper, the new method has the following advantages: (1) It can be employed in the absence of cattle. (2) It is much quicker, requiring only three months as against the ten months required for the cultivator's method. (3) It yields a final product much superior to that given by the cultivator's method. When applied to rice fields, it has consistently given higher yields of grain and straw. (4) The presence of added lime is good for the acid local soils. (*Agriculture and Live Stock in India,* VII, 711-717, 1937.)

The Native Cattle of East Africa

Most stockmen with a wide knowledge of East Africa would agree that there are two types of native cattle, each of which may be divided into local races or breeds. The one, commonest in Western Uganda, Ruanda-Urundi and Western Tanganyika is long-legged, long-horned, with an inconspicuous hump; the other is the familiar, sturdy, large-humped animal such as is found throughout Masailand.

Recently there has been a revival of interest in the natural history and potentialities of the indigenous cattle of Africa, and a most notable publication

on the subject is entitled "A Contribution to the Study of African Native Cattle", by H. H. Curson and R. W. Thornton (*Onderstepoort Jnl. Vet. Sci. and An. Husb.*, 1936, Vol. 7, No. 2).

From this study, which deals with the whole of Africa, it can be learnt that our two types are well-defined anatomically and have different histories.

(1) The *Sanga.*—This is the long-horned animal of Uganda and neighbouring districts of other countries, commonly known as the Ankole, Watusi or Bahema type. Its distinctive anatomical feature is the nature of the hump which, in the language of the authors, is "cervico-thoracic and muscular"; it is comparatively small, composed of muscle, and it lies almost entirely in front of the line of the fore-leg when this is perpendicular. Historically the type is derived by intermixture of the original domestic race of Egypt, the Hamitic Longhorn, still represented in West Africa, and the Lateral-horned Zebu that originally in Africa, under the name of Afrikander. came from Asia, but is found to-day only

(2) The *Short-horned Zebu.*—The distinctive anatomical feature of this well-known type is the musculo-fatty thoracic hump. This appendage may be very large, and it lies above and extends behind the line of the fore-leg. It came from Asia fairly recently in its present form, though Epstein, who has made a special study of this subject, believes that in Asia this type was derived from the intermixture of the Lateral-horned Zebu (Afrikander) and Brachyceros, a short-horned, straight-backed type; a theory that those of us who have seen the modern results of crossing Afrikanders and Shorthorns find hard to accept.

It would undoubtedly make for clearer thinking on the subject if, in future, the names *Sanga* and *Short-horned Zebu* were reserved for these two distinct types of native cattle.

H. E. H.

Man, Land and Water in East Africa

By C. GILLMAN, *C.B.E., Water Consultant to the Tanganyika Government.*

The agricultural and pastoral occupation and exploitation of the land by man is a complicated function of a number of variables. These are based primarily on the structure and configuration of the earth's crust, comparatively stable if measured in terms of human life, and on the much less stable atmosphere, the daily, seasonal and longer period fluctuations of which we try to grasp by the study of climate and its variations in space and time. The interaction of these two prime movers, structure and climate, creates that fascinating pattern of soil, water, life and markets which likewise changes not only from place to place, usually gradually but in certain localities with almost awe-inspiring abruptness, but also, though perhaps less conspicuously, with time. For the earth's surface slowly readjusts itself to the great heavings of the crust and, probably largely caused by periodic or non-periodic alterations in the quantity and quality of forces that pour on to our little globe from the vast expanses of our own solar system and of the cosmos beyond, great and small climatic changes creep backward and forward over land and sea. It is therefore good if *homo sapiens*, who uses this pattern to fill his belly and improve his mind and soul, pauses every now and then to ponder on the constant flux which is the main attempt, if not to solve her laws, at least to grasp their tremendous complexity and to adapt himself, as well as his indomitable will permits him to do, to the exigencies of his very unstable environment. And if this advice is sound for the regions of the earth comparatively more stable as regards structure and climate (like the narrowly confined zone of chestnut-brown soils and well distributed rainfall in the northern hemisphere, or the great alluvial plains of India and China, from which great cultures have sprung), how much sounder must it be for East Africa's still very much "living" belts of tectonic shattering with its wild pattern of dovetailing local climates whose only "normal" feature is their abnormality.

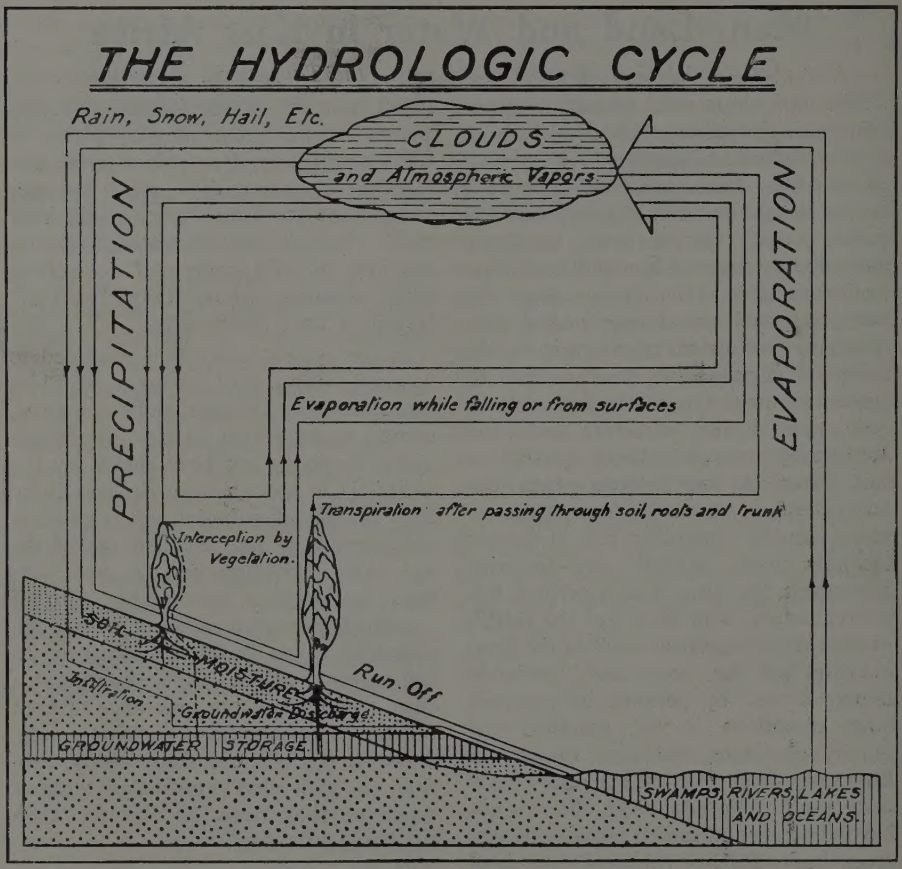
In the present essay it is proposed to deal only with one of the major variables that affect East African land occupation, namely water, which, at least for Tanganyika Territory, has been shown by the writer [1] to have a most decisive influence on the distribution of population and thereby on the potential use of the soil. And it is proposed to deal with this vital factor in the humble spirit of confessed ignorance rather than through premature and, therefore, as likely as not unsound advice, in the hope that a clear statement of our ignorance of East African hydrological conditions may stimulate research and thus, slowly, provide us with that knowledge without which we shall never be able to "keep our house in order".

THE HYDROLOGIC CYCLE

Such knowledge, for a particular region, can only be attained if one thinks of water in all its aspects and understands from the beginning the beautiful, quite simple and universally applicable notion of the hydrologic cycle as depicted in Fig. 1, which is taken with slight modification from [7].

A glance at this diagram shows that the following factors participate in its composition:—

Precipitation (P), either reaching the ground direct or through interception by vegetation, and including



the so-called "occult" precipitation in the form of mist or dew;

Surface Run-off (R);

Evaporation (E);

Transpiration (T) through the life cycle of plants; and finally

Absorption into the Ground (A).

This latter should be subdivided into what is called *Soil Moisture* (M) and *Percolation* or *Infiltration* (I).

The relation between these five factors can be expressed by the well known equation:—

$$P = R + E + T + A^1$$

[1] Neither diagram nor equation takes account of the possibility, or certainty in the opinion of some authors (4, 5), that absorption can also occur by direct condensation from the atmosphere in the air-filled interstices of the soil. If this theory is accepted the formula, with C denoting the interstitial condensation, would read $P + C = R + E + T + A$.

This is mentioned merely to emphasize how little we know fundamentally, as in most other matters, even of this vitally important hydrologic cycle and how careful we must therefore be in drawing practical conclusions from such ever-changing "knowledge" as we pretend to possess.

If one takes P and E for a given locality and time as fixed, or, better, as not easily subject to alteration by man, and writes the equation in the following form: —

$$P - E = a\ constant = R + A + T$$

then it becomes obvious that an increase in the volume of any of the three quantities on the right side must be accompanied by a decrease in one or both of the remaining two quantities. If, for example, man increases run-off by removing the natural vegetation, absorption into the soil must decrease and with it the amount of water available for replenishing ground water or for the transpiration of the artificial (agricultural crop) vegetation by which he replaces the natural cover. But it also becomes clear that the same simple formula will have to be applied differently for different human desires: The water engineer, for example, anxious to fill a "dam" from a limited drainage area, will purposely endeavour to increase R to the detriment of A and T, while the forester will do everything to restrict R in order to increase A and thus to allow as many trees as possible to transpire and live.

After these general remarks it will be useful to explore what definite knowledge we possess of the component factors of the hydrologic cycle in East Africa.

Precipitation

A fortunately ever increasing number of rainfall stations with annually lengthening series of observations already provides data for a first rough understanding of rainfall distribution. By making use of topographical and vegetation maps rather than of hypothetical, though often "elegant", mathematical methods for interpolation we can, indeed, produce at least small scale maps of rainfall "normals" with reasonably close approach to the truth in those areas where denser human settlement has led automatically to a comparatively close net of stations. We are less fortunate with regard to the large empty spaces which may form potential land reserves and into which the meteorologists should send their gauges betimes to provide the data so essential for future planning. But rainfall "normals", however useful these really quite imaginary figures may be, for a preliminary and general characterization of a country's climate, are of little practical interest to the farmer, whose scope and success are largely limited by the variability of the rainfall and especially by the amount and frequency of its minimum; to grasp this latter with certainty we have practically nowhere as yet sufficiently long observational series and in Tanganyika Territory particularly, the ten-year gap between the pre- and post-war observations forms a serious and regrettable handicap, to overcome which many more years will be required.

In the prevailingly semi-arid climate of East Africa deflection from the mean often amounts to 30, 40 or even more per cent, and it is clear that a "normal" rainfall of say 750 mm. (30 in.), which might induce man to grow all sorts of crops, will, with a "normal" variability of 40 per cent (i.e. with the certainty of occasional years of only 450 mm. (or 18 in.), prove disastrous for many crops, especially where this minimum must be expected at frequent intervals.[1]

One should also remember that the rainfall regime typical for semi-arid

[1] Even in the comparatively humid climate of the lower southern slopes of Mts. Kilimanjaro and Meru yearly variations from the mean 30 to 40 per cent seem to be the rule and monthly variations, so important for many agricultural activities, frequently reach or surpass 100 per cent. (9, Appendix II.)

countries is one of narrowly defined and shifting storm routes rather than of more regionally distributed "general" rains, so that even a fairly close network of rain gauges can seldom give data applicable to a whole area with anything like the desired accuracy.

In the higher parts of East Africa, but also in comparatively low-lying belts where tectonically determined exposure to the moisture from the sea creates frequent condensation in the form of mists, "occult" precipitation, generally aided by an interesting symbiosis between trees and lichens [6], no doubt plays an important role in the hydrologic cycle. The "beards" of the lichens increase the condensing surface considerably. In such areas, where a luxuriant natural vegetation in the form of "mist forest" might easily mislead the uninitiated, it would thus be unwise to substitute a crop like tea or coffee which does not acquire the symbiotic habit and would, therefore, immediately reduce the sum total of precipitation. To sum up: Although we are as yet far from really reliable knowledge of our precipitation we are, on the whole, making fair progress in the right direction.

Evaporation

The proportion of precipitation which evaporates while falling or immediately after having reached the surface of the ground or vegetation does not directly enter that part of the hydrologic cycle which affects life on the earth, although it probably contributes indirectly to the amount of occult precipitation where such exists. On the problem of evaporation from the soil itself, all too little is known and there is an ever-growing school of thought which maintains "that capillary rise is a negligible cause of exhaustion of moisture from sub-surface horizons except when there is a standing water table within a very few (four or five) feet of the surface" (Milne, as quoted by Staples). On the other hand, direct evaporation from open water surfaces, including swamps, has a very decisive influence on a country's water budget and the precipitation/evaporation ratio is of the greatest value in the study of the distribution not only of the natural vegetation but of economic plants and their insect enemies [12].

Unfortunately we possess as yet only very few and scattered data which, however, seem to indicate that evaporation from open water in the semi-arid parts of East Africa assumes dimensions of 1 to 2 cms. or more (about $\frac{1}{2}$ in. to $\frac{3}{4}$ in.) per day during five, six or seven months of the year. There can also be no doubt that the regime of the trade winds, with its maximum strength during the drought period, is bound to increase evaporation and that, contrariwise, clouds have a retarding influence. Thus, evaporation is by no means that simple function of temperature alone that so many still fondly imagine; and the recording of relative humidity and the saturation deficit at a few meteorological stations will not help us much towards a correct appreciation of realities which must obviously change greatly from place to place. It seems, therefore, distinctly premature to attempt preparing meteorological maps for East Africa based on one of the many proposed formulas or methods that make use of a precipitation/temperature or a precipitation/evaporation co-efficient [6]. However desirable such maps would be as something infinitely more useful than mere isohyets based on the old-fashioned rainfall "normals", one must, at least for the time being, admit that the material for their construction does not exist, and hope that every effort will be made to obtain it at an ever widening and accelerating rate. In the meantime the best

approach to a true picture of climate still lies, it would seem, in the direction of a vegetation map, superimposed on a good physiographic map of the country and based on an unprejudiced reading of that delicate and universal meteorological instrument, the plant community itself; all the more so since such mapping is to-day made comparatively easy and cheap by observation from the air.

From the practical point of view, our present knowledge of evaporation suffices to warn against exaggerated hopes of solving East Africa's water supply problems by the comparatively simple expedient of open-air storage, about which more will have to be said later.

Run-off, Absorption and Transpiration

If we must, thus, confess that our knowledge of the two fundamentals of the hydrologic cycle, precipitation and evaporation, is as yet far from satisfactory, matters become even worse when we look at the right side of the hydrologic equation (R+A+T) which covers the fate of that part of a country's water resources with which life is mainly concerned in all its many aspects and activities. Experiments and research, designed to obtain reliable data on run-off, absorption and transpiration, and on their mutual interaction, are fortunately increasing in number, especially in countries, like the western United States and the Union of South Africa, climatically and morphologically not dissimilar from large parts of high eastern Africa; and a very promising start has been made in Tanganyika Territory through the enthusiastic and well planned work of Mr. R. R. Staples at the Veterinary headquarters at Mpwapwa [11, 8]. But we are really still quite at the beginning and should, furthermore, not overlook the dangers of too early generalization from a few experimental data culled from a specific set of conditions, to their regional, leave alone universal, application in a world where the complex interrelations between country rock, soil, topography, water and vegetation, not to forget interference with all or any of these factors by man, are never repeated in their entirety from place to place and also change with time through geological hapenings, maturing or deteriorating of soil, plant succession and evolution, and changes in land occupation. Thus, strictly speaking, each locality, every individual plot almost, demands its own individual analysis of the hydrologic cycle; an important point that should be kept well in mind by those responsible for directing native movements on and over the land, or by the settler in search of a homestead.

As run-off, absorption and transpiration are so intimately mixed up and dependent on one another, it seems best to tackle them as a whole when trying to get order into a far from easy subject.

Two undeniable facts stand out clearly: firstly the more water runs off the surface, the less, under equal conditions of precipitation, will enter the ground; and secondly, transpiration can only commence after absorption has taken place and, as long as transpiration acts it tends to decrease the store of absorbed water. Strictly speaking, therefore, the "A" of the hydrologic formula represents only that part of the total water absorbed (be it in the form of soil moisture or of ground water) which is not used up by transpiration. It thus follows that for given values of P, E and R the quantity (A+T) is a constant, although its component parts vary in proportion.

As already stated, A is represented in the ground as the sum-total of soil moisture (M) and percolation or infiltration proper (I). In other words we must dis-

tinguish water percolating and stagnating in the *capillary* cavities of the soil and subsoil only (M), and water percolating in larger cavities (I) [3]. Thus, under certain circumstances, again varying of course widely with geological structure and texture, topography, soil, vegetation and human activities, a large part of A finds its way direct into the ground water proper along the living and decayed roots of trees, fissures or foliation planes of rocks, etc. In addition, it seems firmly established that a soil, still saturated with moisture after the transpiring vegetation has taken its share, can and does eventually contribute all or some of its surplus moisture to the ground water. This being so, it is clear that, again under certain varying circumstances, the quantitative interrelations between M and T as influenced by vegetation cover cannot, as a rule, be used as the only clue in determining the volume of ground water, i.e. of that part of the precipitation that is of primary importance for permanent water supplies in semi-arid countries. Where, as probably is the case in the Mpwapwa experiments on the deep pediment soils under deciduous thorn-bush, conditions are such as to prevent direct infiltration into the ground water (with the result that no locally engendered ground water exists) the use of the simplified formula—

$$P - E = R + M + T$$

may be quite justifiable. But it should on no account be applied to larger areas on which the whole set of conditions contributing to the replenishment of ground water varies rapidly within short distances. For all such areas, and that probably means for any reliable study of regional ground water conditions in East Africa, the full formula

$$P - E = R + M + I + T$$

alone should be used. This makes matters admittedly more complicated but, surely, complication is preferable to errors in judgment based on too far-reaching simplification.

By these statements it is not intended to derogate in any way the Mpwapwa experiments, so helpful and valuable towards a final grasp of an intricate complex; nor to doubt that nothing is further removed from the experimenter's mind than unwarranted and misleading generalizations from his carefully observed facts and figures. But it *is* intended to warn other minds, scientifically less balanced than his, from rushing into such generalizations and, chiefly, to press for a manifold multiplication of similar experiments under as many dissimilar conditions as possible.

A whole string of important relations between water, soil and vegetation are urgently awaiting elucidation and before this has been achieved the practical man, be he farmer or water-engineer, administrator or forester, will find himself hampered by difficulties in every direction when trying to plan in the right way and will, thus, only too frequently be pushed back into the old attitude of trusting to trial and error (sometimes called "the pioneer spirit" or the "Pilgrim Fathers' complex"). To mention only a few of these relations: under what conditions can grassland form a better safeguard for the maintenance of an adequate underground water supply than the various types of woodland? How is water supply affected through the large scale replacing of woodland by grassland which has gone on for many generations, and continuously under our eyes, in the form of the well known "Cultivation Steppes", with particular emphasis on the various phases in the history of their development? Are those right or wrong who, like the writer, still strongly uphold the old established and historically so well documented rule that

a forest cover of its mountainous ground is the safest way to regularize a country's water economy? Does the fringing forest that accompanies permanent or semi-permanent streams far out into the arid foot plains of our mountain blocks use more of the ground water for transpiration than it protects against evaporation by its double function of wind-break and shade? What, to draw the animal kingdom into the picture, is the role played by termites in the redistribution of the soil water content within the sphere of their activities? It will readily be seen from these few examples that the field for investigation bristles with unsolved problems.

Generally speaking, each vegetation type represents a subtle adjustment to the available moisture supply; a dictum which becomes particularly clear under semi-arid conditions, be these climatically or edaphically caused. Under more humid conditions, especially in full-humid tropical rain forest or in many temperate forests growing under a rainfall more evenly distributed through the year, there appears to be a surplus of soil moisture which even a most luxuriant vegetation cannot use up in transpiration. This surplus may either benefit the lower ground water or, if retained in the upper layers, help to regularize surface run-off by the classical "sponge" action. And vice versa, where soil moisture is just sufficient to maintain, say, evergreen thicket or similar formations, it is quite logical to suggest that, by replacing such formations by a less exacting type (e.g. grass) a surplus of soil moisture may be made available for ground water replenishment.

Apart, however, from its influence on soil moisture through transpiration, vegetation can also markedly affect evaporation, run-off and infiltration and can thus, directly or indirectly, contribute to the volume of ground water. Where, therefore, interrelations of vegetation and ground water form the primary subject of investigation it is wise to apply the general formula in its entirety by attempting to determine how every one of its constituent members is affected by a specific type of vegetation. Only then shall we be able to state definitely which type is the most useful for the conservation of ground water in a given environment or, in other words, *for which vegetation type is the balance of its beneficial influence on all the members of the hydrologic formula a maximum.*

Water Conservation

After this review of fundamentals, as exhaustive as a short essay permits, and designed to serve merely as a first orientation in a most intricate field of human knowledge, the outlines of possibilities for improving the hydrologic cycle from the human point of view will now be given. Such improvement is particularly desirable in the vast regions of East Africa where, owing to the lack of a reasonably reliable domestic water supply throughout the year, population density is very low or the land even quite unoccupied, although the general overhead climate would certainly permit the growing of subsistence and, to a certain extent, of export crops. Until these regions are provided with permanent water they can by no stretch of the imagination be looked upon as land reserves against the future when the present more closely settled cultivation steppes or the well-watered highland patches will, through exhaustion or deterioration of soil and water, no longer maintain their dense populations of agriculturalists and pastoralists.

The fight against tsetse and tick naturally also enters the problem of these land reserves, in any case where peoples

are concerned who cannot, or think they cannot, live without cattle. But water is and will always remain the primary necessity without which settlement is unthinkable.

We cannot alter climate and must accept as we find them rainfall volume and distribution with all their vagaries in time and space. But we can and should see to it that the efficiency of rainfall is not only not decreased, as unfortunately is so often the case by irrational exploitation of new lands, but is increased with all the means at our disposal. There are those who shirk their responsibilities in this direction by maintaining that, over vast parts of Africa, rainfall is actually decreasing, and despondently blame climatic changes if their fields and grazing deteriorate and their wells and streams run dry. They forget that nowhere has such continued secular decrease of rainfall been proved and that, even were it proved, efforts to increase its efficiency would be all the more required.

To improve rainfall efficiency means to increase that part of the precipitation which in one way or another, as soil-moisture, ground water or permanent water courses, benefits life. Generally speaking this can best be done by regularizing run-off and well-planned schemes for doing so should be the primary concern of governments and individuals alike. Such schemes must extend throughout the drainage area, starting in the upper reaches by careful protection of the vegetation on the watersheds and in the head valleys; descending the middle reaches in the shape of anti-erosion methods of grazing and tilling; and ending in the lower reaches by careful training of rivers. The two gravest—if not the only—causes of the rapid deterioration of rainfall efficiency that we are witnessing at the present moment in so many parts of East Africa are deforestation and soil erosion, and any steps taken to counter these evils will automatically improve the country's water balance.

Whatever measures are taken, however, to reduce run-off it is clear that a large part of the water which falls on the ground does actually descend into the depressions of the earth's surface, and must, in fact, do so in order to keep the hydrologic cycle moving. But from times immemorial mankind has managed to retain for its own immediate use parts of this natural run-off, especially where marked seasonal fluctuations exist, by storage against the lean periods of the year.

Furthermore, just as evaporation from the open water surfaces in which the run-off collects is essential for the maintenance of the hydrologic cycle, transpiration by the vegetative cover of the earth is likewise an integral factor for such maintenance and, in addition, serves another vital purpose as regulator of the oxygen content of the atmosphere. Without plants, animals would not only have nothing to eat but would very soon have to stop breathing. A large-scale interference with vegetation might therefore result in a disastrous upsetting of a, probably, very delicately adjusted equilibrium, while the storage of part of the run-off, especially if planned properly and with due regard to the legitimate demands lower down in the drainage basin, need not as a rule lead to serious consequences.

Before discussing the various kinds of storage and their applicability under

[1] Comparatively large numbers of Bantu do, in fact, live without cattle in tsetse-infested savanna country as, e.g., the 980,000 inhabitants of the eastern and southern Provinces of Tanganyika Territory.

East African conditions it is necessary to realize, through concrete examples, the relative insignificance of the volumes of stored water required for the domestic use of a scattered population of farmers and pastoralists.

Let us assume that the country to be made accessible for permanent occupation by provision of stored water has an annual precipitation of 700 mm. (27.5 in.), a drought season of 180 days, during which the stored water is the only available supply, and that during the remaining days 20 per cent of the consumption is drawn from storage. Evaporation is estimated at 2 cms. per day during 180 days which would amount to 3.6 m. or, say, 4 m. per annum (157 in.). The planned-for population and cattle density is 20 people with 20 head of cattle per square-kilometre (about 52 per square mile) and the daily consumption of water is taken as 25 litres (5.5 gallons) and 10 litres (2.2 gallons) respectively per head of cattle or person.

Under these generous assumptions the water consumption from storage works out at:—

Men	$20 \times 10 \times 180 = 36{,}000$	litres
Cattle	$20 \times 25 \times 180 = 90{,}000$	„
Total (during drought season)	126,000	„
Add 20 per cent (during rest of year) or say	24,000	„
	150,000	„

Total annual consumption from storage 150,000 litres, or 150 cubic metres.

To assure this in a "hafir"-type reservoir of $10 \times 5 \times 3 = 150$ cbm. with an evaporation depth of 4 m., the storage capacity must be $10 \times 5 \times (3+4) = 350$ cbm.

For a shallow reservoir, of the "dam" type, of $10 \times 15 \times 1 = 150$ cbm., and the same evaporation, the capacity would have to be $10 \times 15 \times (1+4) = 750$ cbm.

A rainfall of 700 mm. produces $0.7 \times 1000 \times 1000 = 700{,}000$ cbm. per sq. km. so that the percentage of the total rainfall that must be stored to supply 20 people and 20 cattle throughout the year works out at—

$$\text{in "hafirs"} \left(\frac{\text{surface}}{\text{depth}} = \frac{50}{7}\right) \quad 0.05\%$$

$$\text{in "dams"} \left(\frac{\text{surface}}{\text{depth}} = \frac{150}{5} = 30\right) \quad 0.1\%$$

In other words only 5/10,000 of the annual rainfall are required for deep, and 1/1,000 for shallow reservoirs; surely, one should think, sufficiently small volumes to render their storage a comparatively easy matter; and a cause for wondering why man in East Africa has not long ago though of such an easy way out of his difficulties. A closer investigation will soon show that, unfortunately, the problem is not quite as easy as it looks.

For open air storage one can conveniently distinguish three types: large reservoirs, small so-called "village dams" (of the Deccan type) which store water *above* ground-level behind earthen or other dams across a valley or depression; and "tanks" or the Sudan "hafir" type) dug *into* the ground. All these types suffer from the drawback of prolonged high evaporation as well as from the large load of silt usually carried into them by the run-off in semi-arid countries. The smaller the ratio of surface to depth the better can the evaporation drawbacks be countered; but one should never forget that under East African climatic conditions, which rarely provide sufficient water at the right time for sluicing out the accumulated silt (in any case a costly process hardly conceivable under the economics of native and white settlers), the capital value of any open-

air reservoir is bound to decrease as time goes on and complete silting up is the inevitable fate.

For large reservoirs the desideratum of a combination of small surface with great depth can generally not be fulfilled in the mature topography of the East African plateaux, and where mountain gorges might offer more favourable conditions the country is usually so well provided with permanent running water that storage is not required. There are, of course, exceptions, and the possibility of supplying small townships in the neighbourhood of isolated hills or mountains in areas with a distinct drought season from such reservoirs should always be kept in mind. They will, in any case, prove useful experiments; but the water derived from them will certainly be costly.

Small farm or village "dams" might in certain regions prove a more attractive and feasible method of storing part of the superfluous rainfall and may well come within the economic limits of native communities and small alien settlers. They are well worth experimenting with on a much wider scale than has been done in the past, but topographical conditions will probably restrict their usefulness in many areas.

The "hafir", finally, is another type which deserves much more attention than it has had so far. It is, or can be made, the most favourable type with regard to surface/depth ratio; but suffers from the drawbacks that it must be built into practically impermeable soil and that the most suitable soils are generally linked with a topography so gentle that it is difficult to guide the run-off from it into the excavated tanks.

Enough has been said to show, on the one hand, that neither village dams nor "hafirs" are that panacea which many enthusiasts somewhat rashly consider them to be; and that, on the other hand, they are yet sufficiently promising to call for a regional survey of our vast lands without permanent domestic water, with a view to deciding where topographical, run-off and soil conditions are suitable for the one or the other.

In many semi-arid and arid countries a semi-open storage reservoir has been developed in the form of the "cistern", whose advantage lies in greatly decreased evaporation due to the protective shelter of the roof under which it is built. This system or its modern equivalent of galvanized iron tanks is, of course, already fairly widely used where European dwellings have been pushed into the semi-arid margins of the better watered centres of white settlement. The prevailing types of native roofs, however, are quite unsuitable to fill cisterns and the unavoidable use of masonry and concrete, or of corrugated iron takes an otherwise splendid solution of the storage problem outside the reach of native economics. But with the spread of native prosperity such as is hoped for through the introduction of the so-called "small holdings", the corrugated iron roof and with it an inexpensive design for a simple cistern might well be developed in time.

Against all these artificial open-air or semi-open storage methods stands the natural underground storage which, in view of the many drawbacks that we find attached to the former, is, where available, probably still the best and securest water supply of semi-arid lands and its maintenance and increase are, therefore, of vital importance. Once a part of the precipitation has reached the ground water it is in most cases safe against losses through evaporation, the exception to this rule being the instances, rare in East Africa, of a very high ground water table or a vegetation dependent on

such. For the supply of water, ground water interests man as feeder of natural permanent springs and of artificial wells and boreholes. The "crystal spring", the symbol of happy settled life praised by the poets of all races and ages, is of course the most valuable and at the same time cheapest water supply that man can think of; and this "present of the Gods" he has squandered in the past, and still is squandering to an alarming extent today, by decreasing the efficiency of rainfall and thereby turning land once well provided with springs into semi-desert or even desert. But springs do not only serve those who dwell in their vicinity. By keeping our permanent streams supplied throughout the year, they spread their benefit far over the land and permit long, though narrow, strips of ground along these ever-flowing "stranger" rivers to be occupied in an environment otherwise unsuitable for permanent settlement.

That part of the groundwater which, in the absence of suitable topographic and geological conditions, does not find its way to the surface can be tapped by wells and boreholes, and modern technical progress in the arts of drilling and pumping is pushing the practical limits of ground water exploitation deeper every year. There are, however, very severe limitations of an economic nature where groundwater supply to poor native communities is concerned, so that, for all practical purposes, one is restricted to the shallow ground water that can be reached by cheap wells. Another drawback is the everywhere apparent inability of the native to look after pumps or any appliance for hoisting water more complicated than a bucket and rope. No doubt very gradually these drawbacks will be overcome, but for the time being it is perhaps wisest not to base schemes for improving permanent domestic water supplies in native areas on ground water tables below, say, 30 m. (100 feet) or so.

Sub-surface dams in sandy river beds, preferably with a simple and reliable appliance for syphoning off the stored water, are another way of exploiting the shallow ground water in certain suitable areas.

All this notwithstanding, there can be no doubt that our ground water resources are among our most valuable, if not *the* most valuable asset, that their extent should be accurately mapped, the possibilities of their improvement be carefully studied with the help of the geologist and plant ecologists and every possible precaution be taken by the reafforestation and anti-soil erosion measures, against further deterioration of rainfall efficiency. The destruction of a country's arable soils is bad enough; infinitely worse is the concurrent destruction of its ground water regime because it is a process faster even than that of soil deterioration and, therefore, liable to put areas that still possess soil out of action because there is no more water for the tillers of the soil.

Irrigation

One cannot leave the subject of "Water and the Land" without at least a short reference to irrigation. The layman is apt to shout for irrigation schemes without knowledge of their implications. Hence, to start with, a few definitions: In ordinary language irrigation means any artificial spreading of water over soil that lacks natural moisture. In technical and agricultural practice we must, however, carefully distinguish between two very different types of irrigation: floodwater irrigation that takes the water from permanently flowing silt-carrying rivers; and reservoir irrigation that stores the wet weather spates of intermittent streams in reservoirs where the water loses much of its

fertilizing silt and is, by evaporation, increasing its salinity.

We must further distinguish two types according to the nature of the soils to be irrigated, namely the irrigation of alluvial and of residual soils.

The great accumulations of mankind in ancient and modern times alike (Babylonia, Nile Valley, Gangetic Plains, China, Plains of the Po, etc.) are all based on floodwater irrigation of alluvial lands which, therefore, and before the quite recent development of our West European and North American industrial agglomerations, alone must be held responsible for the greatest population densities as yet achieved on this earth. It would be quite wrong, however, to look for similar development in East Africa, although there are still ignorant minds who are dreaming of such possibilities. Several cogent reasons will make this clear. In a region disturbed in geologically recent times by severe tectonic shattering, alluvial lands are scarce and most of the courses of our few large permanent streams lie, therefore, through lands covered by the eluvial soil of the pediments of upraised crust blocks. These soils are liable to become alkaline unless very copiously flushed by irrigation water, a process that would quickly increase the water requirements and would, quite apart from the increased cost, be probably in most cases impossible, due to the lack of sufficient quantities of water. The few alluvial lands traversed by permanent rivers, for example the Kilombero Plain and Rufiji Delta in Tanganyika Territory, are subject to large-scale annual inundation to prevent which would be beyond the means at the disposal of the administration under present world economic conditions.

The precariousness of floodwater irrigation in East Africa has recently been emphasized in an admirable report [2] on the Tana River in Kenya Colony, which shows clearly that, under the best of circumstances, such a scheme would be a protective rather than a productive one.

As regards reservoir irrigation in East Africa, there is a general consensus of opinion among those best entitled to speak on the subject that, in view of South African experience, such schemes should be left severely alone. There thus remain only minor projects or existing irrigation practices whereby a still abundant water supply from high mountains or crust blocks can be or is being utilized to get additional harvests out of the debris fans along the scarp foot or of the soils on the interfluves. These will require careful local studies, as those reported in [9], and will for years to come probably be the only ventures into irrigation that the East African administration will, or should, contemplate

Conclusions

This essay may, and probably will, to some readers look unduly pessimistic. But is this not merely the old controversy between the orthodox form of optimism based on ignorance versus that very different kind of optimism which, because it is shouting for knowledge prior to action, is so often mistaken for pessimism? It would not shout if it were not firmly convinced that increased knowledge leads to improvement of even quite hopeless-looking conditions. But call it whatever you like, we shall in this modern world of ours never achieve anything of real and lasting value unless we observe facts, instead of allowing ourselves to be ruled by fancies; and then build carefully and intelligently on the sound basis of such facts and with as little bowing as human nature permits to what we fondly call our indomitable will.

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Farm Fencing—Part IV

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ERECTING THE FENCE—*contd.*

Wiring Plain Wire

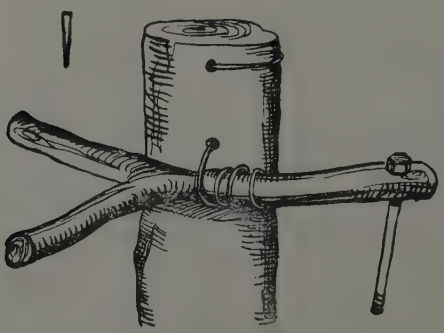
Put the coil of wire on the spindle or reel before cutting the ties. The outside strand is pulled out, threaded through the posts and fastened to the first straining post. If two or three men haul on the wire while it is being fastened a neater job can be done. Run out the wires, haul by hand, and cut to required lengths. A native assistant should be instructed not to pull out wire in a jerky manner; he should be provided with an old sack to put over his shoulders to carry the wire and told to walk away steadily.

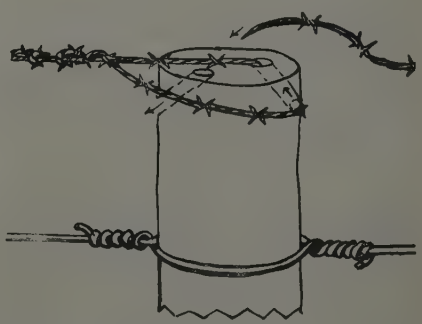
When fixing wires to straining posts, pass them round the posts in alternate directions. If all are passed round the same way the post is liable to twist and come adrift from the stay.

Strain the bottom wire first and then the top plain one. If the post has a tendency to draw up, this method will help to counteract it by tightening slightly the bottom wire.

The usual patent strainer has a short handle, chain and jaws for gripping the wire and another loose chain with jaws. A short length of wire or chain can be tied round the straining post and one piece of the patent strainer attached; the other piece takes the wire to be strained. The end of the wire to be strained is passed through the post hole, the strainer fixed and the wire tightened up. After it is fastened the strainer is removed.

As a straining tool a forked branch is very satisfactory. A small hole is bored through the stem through which the wire is passed and the two arms of the branch are used as handles and the stem as a roller. Three men can strain a wire satisfactorily with this. In this case, hard, dry, wooden one-inch plugs are hammered in the hole at the straining post and at the nearest fencing post before the strain is relaxed. These plugs should be six inches long, round and pointed, and be put in so that the pull of the wire when released by the roller tends to draw them further in.





FIGS. 1 AND 2

The fork or a yoke can also be used as a lever by placing the foot of the lever against the straining post, attaching the wire at the correct height to give a fairly straight pull, and hauling outwards.

Two lengths can be strained to the one central post. This is convenient with a patent strainer, but if a fork is used the first set of wires are in the way when the second lot are strained, and in this case it is better to work along from one strainer to the next.

Do not strain wire when the ground is very wet.

Wiring Barbed Wire

A stout pair of gardening gloves saves a lot of small cuts at this work. A claw hammer is useful in helping to pull the wire, but the hand should be protected by a piece of sacking.

If barbed wire is to be threaded, be careful to see that the holes are large enough; threading is not recommended. If staples will not hold or go into the wood, a middle line of barbed wire can be laid in a slight cut in the posts and tied with No. 12 malleable steel wire or laid through cuts into holes bored near the edges. A top wire is best fixed as in Fig. 2.

New barbed wire is always supplied on wooden reels and, for unwinding, a stout pole thrust through the hole is sufficient. Use the swivelled handle and allow the wire to untwist while pulling out. If a long length is to be unrolled, one or two men should go along the line to help haul, untwist and free the wire when it catches anything. It must be paid out slowly and laid on the ground a few feet from the line of the fence to avoid getting it tangled before it is completely untwisted. Wire should not be in tension when cut. When using a roller for straining, a useful way of fixing barbed wire to strainers is illustrated. The two holes should not be quite in line. A wooden plug holds the wire while it is being fastened. This method is only useful with strong woods; cedar would split at the top if a peg were hammered in.

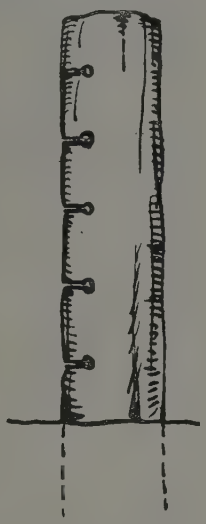


Fig 3

When the wiring is finished the work should be inspected, and where the bottom wire runs too close to the ground an extra post should be put in to raise the fence to the correct level. If care is taken when marking out the line this should not be a big task. The post should be bored near one edge and cut to allow the wires to be slipped in. Knocking in a wire through a narrow cut will weaken or break it.

If the fence is too high, the extra post is fitted with a foot-plate, hung on the wires, and held down while being rammed.

Fixing Droppers

Wooden droppers can be nicked with a saw or knife and be wired on with No. 12 or 14 gauge galvanized malleable wire. If unseasoned they will shrink and work loose; in this case it is better to

bore small holes at the right spacing, pass short lengths of tying wire through and twist the ends round the fence wires. The bottom of the dropper need not be more than two inches below the bottom wire. Where elasticity is desired, care should be taken that droppers do not rest on the ground.

The spacing of droppers largely depends on the strength of the wires, except where they are put close together for visibility. The stronger the wires used, the tighter they can be strained and the further the droppers can be spaced.

The New South Wales fence has droppers 16½ feet apart; this is about the maximum useful distance. Twelve feet is usual, and many people put them closer still, until the fence begins to acquire the qualities of a woven netting fence. A long thin rod for measuring the distance from dropper to dropper is useful when fixing them.

(To be continued)

Notes on the Economic Possibilities of Blue Sisal (*Agave amaniensis*)

By G. W. Lock, *N.D.A., A.I.C.T.A., Agricultural Officer, Department of Agriculture, Tanganyika Territory.*

The production of blue sisal (*Agave amaniensis*) is still in the experimental stage and has not yet developed into an economic proposition. Since the discovery in 1929 of a few plants growing in a remote corner of the East African Agricultural Research Station at Amani, lack of planting material has prevented the cultivation of blue sisal on any extensive scale. The position is rapidly changing, for bulbils and suckers are now distributed to estates in larger numbers, so that the area under blue sisal is increasing annually. Within the next few years fibre should be forthcoming in exportable quanties.

Meanwhile, the possibility of *A. amaniensis* becoming a supplementary fibre crop for sisal estates in East Africa continues to be investigated. Experience gained so far with both the crop and the fibre may be of interest to prospective producers.

Vegetative Characteristics

The attractive appearance of blue sisal seldom fails to excite the attention of all who see it for the first time, including those who profess little enthusiasm for agaves. The long heavy smooth leaves with their healthy "bloom," together with rapidity of growth, combine to give the impression that blue sisal is superior to the sisal of commerce (*A. sisalana*). To what extent this impression is correct has not been determined fully; at present, the future of the plant seems to be hopeful.

Although it produces slightly fewer leaves than common sisal, this is compensated for by its taller growth and the heavier nature of the leaf. The time required from planting to poling is still rather uncertain as it has varied from four to seven years.

Fibre Characteristics

Examination of the fibre characteristics of blue sisal by the Amani staff indicated that its striking external appearance did not belie its potentiality as a producer of high grade fibre. From leaf sections, Nutman [2] [3] showed that blue sisal has many more fibres per leaf than common sisal. In addition to being finer, the proportion of peripheral, or "mechanical," fibres to internal, or "ribbon," fibres is twice as great. The higher proportion of fine fibres is expected to have an important influence upon the spinning qualities of blue sisal fibre. Furthermore, the individual peripheral fibres are denser in structure and more compact in cross-sectional shape, which accounts for the higher intrinsic tensile strength of *amaniensis* fibre compared with *sisalana* fibre. Its greater length cannot be disputed. The percentage of fibre in the leaf is much on a par with ordinary sisal at the same stage of development. Small samples of fibre submitted to the authorities at home elicited encouraging reports.

Blue Sisal Grown on a Field Scale

One of the earliest opportunities of growing blue sisal on a field scale under conditions typical of sisal producing areas of Tanganyika occurred at the time the Sisal Experimental Station was started near Tanga. By March 1935 the quantity of suckers available at Amani sufficed to plant about six hectares (fifteen acres) at Mlingano.

This area is planted on a deep red loam soil derived from gneiss. Beyond clearing derelict Ceara rubber (*Manihot glaziovii*) and bush in the ordinary way with hand labour, there was no preliminary cultivation. 2½ m. × 1½ m. (8.1 ft. × 4.9 ft.) spacing, giving a density of 2,666 plants per hectare (1,079 per acre), was adopted. Subsequent upkeep comprised five weedings in 1935 and again in 1936, and four cutlassings in 1937. Sucker growth was removed periodically for distribution to estates. Therefore it cannot be said that this trial area has been given any special treatment over and above normal cultural practice on a sisal estate.

The annual rainfall was fairly constant at a little more than 50 inches per annum. The plantation made good progress and was forward enough to enable a first cut to be taken in November 1937 or thirty-one months after planting. Messrs. Consolidated Sisal Estates of East Africa Ltd., kindly undertook the task of cutting and decorticating the leaf.

Cutting and Decortication

Fifteen leaves were left on each plant after cutting, which is not severe although it sounds so. In blue sisal, with its more upright habit of growth, the upper leaves surround the central spike more closely than in common sisal. The length of the leaf varied between 100-140 centimetres and it was not unwieldy to handle.

Decortication was carried out on a modern machine. In order to ensure well decorticated fibre it is necessary to set the knives closer to the concave than for ordinary sisal owing to the finer character of the fibre. The thick butt ends are hardest to clean properly; sometimes fleshy strips are left which are difficult to remove from the finished product. Both length and fineness of the fibre demand careful handling in the brush-room.

Yield of First Cut

Allowing for pig damage, to which common sisal is also liable, the area at Mlingano yielded 2.4 tons of fibre per hectare (about 1 ton per acre). The extracted fibre percentage averaged 2.98 per cent, while waste losses amounted to 22.8 per cent of the total fibre. Of the total harvest of 13.8 tons, 84.4 per cent was No. 1 grade, 6.4 per cent No. 2 grade, 6.1 per cent No. 1 discoloured and 3.1 per cent tow. Bearing in mind the wide spacing as well as the early commencement of cutting, these results compare satisfactorily with those generally obtained with common sisal in this locality. After the first cut had been taken, the plantation gave the impression that the spacing in the row could have been closer than 1½ m., which might have enhanced the yield.

The fibre has been sent to England for a market valuation, and also to Dr. Gibson at Lambeg, and to Germany for spinning tests. It is too soon to receive reports on these consignments.

Pests and Diseases

The sisal weevil (*Scycophorus acupunctatus*) exists in the Tanga district and some people are inclined to think that blue sisal is more prone to weevil attack than common sisal. It is certainly not immune to weevil but in the plantation at Mlingano (not far removed from sources of infection) weevil has only been responsible for the small loss of 0.3 per cent of the plants to date. Weevil attack was sporadic, confined to a few individual plants which it damaged badly, whereas in common sisal it is usually more widespread and the damage inflicted on each plant is not so severe.

A new form of weevil damage resulted from the insect burrowing through the underside of the bulbous portion of the leaf butt, thereby staining butt end fibres.

Inclusion of the damaged fibre may be avoided by not cutting too close to the bole, or else attaching a knife to the decorticator to slice off a thin piece of the butt as the leaves pass through the machine. A drawback to *amaniensis*, more particularly on older plants, are the massive leaf butts left on the bole after cutting. These may become a breeding place for weevil. Given reasonable plant sanitation, it is not thought at present that weevil constitutes a limiting factor to blue sisal cultivation in this district.

A small area of young *amaniensis* suffered from sun-scorch last August, but the symptoms did not spread.

Utilization of Blue Sisal Fibre

Supplies of blue sisal fibre in quantity only materialized recently when the Mlingano plantation was cut. Prior to this large-scale manufacturing, trials at home to ascertain whether a demand might rise for this fibre were precluded. Last year, however, Major von Brandis, of the United Sigi Segoma Estates, Ltd., sent four bales to a spinning firm in Bremen who carried out a series of tests and later rendered a useful report upon the manufacturing possibilities of blue sisal fibre. Their comments are tentative because of the limited amount of fibre for experimentation, but help to illustrate how blue sisal ranks amongst the hard fibres of the world. Permission to mention the salient points raised in this report is gratefully acknowledged.

The fibre supplied originated from some plants on Major von Brandis's estate and also leaf from older plants which he transported from Amani. Decortication was done on a modern machine; the fibre was artificially dried; some was brushed and some unbrushed. The consignment was all No. 1 grade, one-third of it from first cut and most of the remainder from third cut.

The spinners' criticism of the fibre submitted is as follows:—

Length.—Length of the hanks varied from 120-170 centimetres, being mostly 140 centimetres long. A bale of first cut had some of the longest fibre.

Colour.—The colour of the brushed fibre was rather better than that of the unbrushed fibre. The best was white and glossy; one bale was slightly greenish and variegated. Butt ends of the unbrushed fibre tended to be "brownish".

Feel.—In general the feel of the fibre was "soft", some of the third cut being described as "very soft". Butt ends of the unbrushed fibre were "hard" in the case of the first cut and "hard and coarse" for the third cut, though the butt ends of the brushed fibre, chiefly third cut, were designated as "normal". There was a tendency for the tips to be "like oakum".

Cleanliness of the fibre was marred by the presence of "blue fleshy bits" which possibly caused the assessors to remark that brushing was insufficient.

Moisture Content. — As mentioned previously, the fibre was artificially dried. Samples taken from the centre of the bales had an average moisture content of 10.1 per cent, which compares satisfactorily with 10.9 per cent for African Sisal No. 1, and 10.5 per cent for Java/Cantala/T, but not so favourably with 8.3 per cent for highest grade Java sisal. While not attaching too much significance to the figure for blue sisal (since more tests are required) the spinners seemed to think the moisture content should not exceed that for Java/A sisal. A chance existed of absorption of moisture during the voyage due to the special form of packing used.

Strength Tests. — Samples for fibre strength were taken from the middle of the hank, 60 centimetre lengths being

used. Compared with Java fibre, single blue sisal fibres are firmer, but when tips and butts are taken into consideration blue sisal is more variable throughout its length than Java sisal. Allowance must be made for this when comparing fibres for "degrees of fineness" as tabulated below:—

Fibre	Degrees of Fineness	Percentage
Java/Cantala/T ..	4·950	100·0
Java/A	3·010	60·8
African Blue Sisal ..	3·700	74·7
African Sisal No. 1 ..	2·940	59·4

A "degree of fineness" is not defined in the report and so these results cannot be compared with Nutman's figures [2].

On the understanding that the figures determined for blue sisal need further confirmation, comparisons for breaking strains were stated to be as follows:—

Fibre	Breaking Length (km.)	Comparative Breaking Length	Percentage
Java/Cantala/T ..	32·2	32·3	100·0
Java/A	31·8	19·3	60·0
African Blue Sisal	34·9	26·0	80·5
African Sisal No. 1	31·5	18·7	57·9

The breaking length is that length of a single fibre which if suspended from one end would break under its own weight. "Comparative breaking length" is obtained by multiplying "% fineness" by "breaking length". Butt ends and tip ends were not tested for strength.

Summary.—In the report the conclusion is formed that blue sisal may be classified amongst the finest of working hard fibres and given quality was as uniform as that of Java sisal, its value would range higher than African Sisal No. 1 and Java/A grades.

Most criticism was levelled against the unequal quality of the fibre. It is stressed that if Java/A prices are to be hoped for, better treatment in the estate factory is essential, particularly in regard to sorting and grading for length. A suggestion is offered that the leaves should be cut so as to exclude the hard butt-end fibres, which detract from the uniformity of the product. The writer is informed that this practice is customary in Java with common sisal.

Spinning Tests

Trials with spinning twine and string were made with the unbrushed fibre. The "oakum-like" ends and the fleshy spots were not removed during manufacture and later appeared in the finished article. Yarns of 2-ply and 3-ply were spun to lengths of 540 m. per kg. and 900 m. per kg., that is, fairly stout string. For strength, stretch and uniformity the *amaniensis* compared somewhat unfavourably with Java/A sisal, except in the 3-ply 900 m. yarn, where the coarseness of the string produced helped to hide the differences between the two fibres. The decision arrived at from these tests was that unbrushed blue sisal fibre is not very suitable for spinning either twine or coarse string.

The brushed fibre was not made into twine because it was wished to see how it compared with Cantala and Java/A sisal, which owing to their higher price are usually utilized for the better and finer types of string. After the experience with the unbrushed fibre, the butt and tip ends of the brushed blue sisal were cut off.

The report goes on to say that the prepared *amaniensis* goes over the machines well and when spinning up to a running length of 1,250 metres per kg. (a good medium sized parcelling string) the manufacture is good. In spinning up to greater lengths, such as 1,500 m. and

2,000 m. yarn (equivalent to fine string), the process is not so easy because of the yarn breaking frequently and also irregularities in the yarn. The results were bad with 2,500 m. yarn and the spinners feel that blue sisal cannot be considered suitable for this.

Cantala is often used for these finer twines. Figures are given comparing breaking strength, stretch and uniformity of 2- and 3-ply polished strings of 1,250, 1,500, 2,000 and 2,500 m. per kg. respectively which were prepared from *amaniensis* and *cantala* separately. In each case *amaniensis* did not come up to the standard of *cantala*. On the other hand for 2-ply and 3-ply 1,250 m. per kg. string the *amaniensis* compared well with Java/A (commonly used for such cordage) and was superior to it in some respects. Samples of these strings may be seen at Mlingano.

Finally the spinners emphasize that further tests with blue sisal over a longer period are needed before a definite opinion can be expressed upon the value of this fibre in cordage manufacture. They mention that one of the difficulties to be overcome with hard fibres in general is their lack of uniformity, particularly with African Sisal No. 1 and to a lesser degree with Java/A sisal.

The tenor of the report suggests that if blue sisal receives careful preparation in the estate factory and if uniformity in quality and colour can be raised (for example, by excluding the hard butt-end fibres) then it would be equal to or perhaps better than the best Java product. It is only fair to point out that the fibre submitted for these tests was not produced under ideal conditions because the leaf had to be transported a long distance before decortication.

As far as can be seen to-day there is a possibility that blue sisal may eventually become a specialized product. Its fibre might be used successfully in spinning certain of the finer classes of twine for which common sisal is not so well fitted. Incidentally some estates have found that decorticator ropes made of blue sisal wear longer than ordinary sisal ropes.

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Essays in Applied Pedology

II—Some Factors in Soil Mechanics

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[In the May, 1937, number of this Journal (Vol. II, pp. 465-469) extracts were given from a survey by Sir John Russell, written for the Royal Agricultural Society of England, summarizing certain recent advances in soil physics. The headings concerned the significance of soil crumbs, and moisture relationships. In the present article the first of these subjects is dealt with more fully, in an East African setting.]

INTRODUCTION ON TERMINOLOGY

In this discussion we are to be concerned with the ideas of *texture, consistence, structure* and *tilth.* I therefore begin by explaining the senses in which I shall use the words, more especially as the first of the four, as applied to soil, has hardly yet outgrown a loose usage of the past that has been responsible for delaying a clear understanding of the subject.

Suppose we treat a soil sample, by prolonged shaking in water and other necessary means, so as to undo all its natural cohesion and liberate each sand, silt and clay particle from its neighbours. If we measure the coarseness or fineness of the assemblage of ultimate particles so obtained, the result is spoken of as the *texture* of the sample.

In classifying soils according to this property there is a difficulty in the terms of verbal description that have to be employed. Texture can be judged pretty well in the field, with practice, by rubbing moistened soil between finger and thumb until all lumps and compound granules have been worked down to a paste. In thus arriving by sense of touch at an opinion of texture the observer must be careful to separate his appreciation of the ultimate fineness of grain of the sample from what he perceives at the same time of its other mechanical properties. These other properties are those described below as consistence and structure. They are of such interest and importance that practical men have long been accustomed to judge them along with texture by testing the "feel" of a sample picked up in the field. In doing so they have not usually analysed their result but have tersely described the total of the observation, and the words that have entered the language for this purpose express the "feel" as a whole, not merely the textural element in it.

When therefore, in looking more critically into soil properties, we come to describe texture as a separate character, the available words of common language fail us; in ordinary usage they imply too much. The difficulty is not seriously felt with coarse-grained soils, the gravels, grits and sands, but such descriptions as *sandy loam, loam, clay loam* and *clay*, which for lack of better are in common use for the medium and fine-textured classes, carry with them notions of friableness, crumbliness or stiffness from their ancient origin in the conversation of English farmers. It will be seen presently that to imply these qualities when texture alone is being described may be seriously misleading when the discussion is no longer of familiar English soils. We need in fact a new set of terms (When they are introduced they will be complained of as incomprehensible scientific jargon.) In the meantime, in a discussion of particle size irrespective of anything else, we have to be guarded and circumlocutory if we are to avoid misunderstanding, or else we

must abandon verbal description and report texture by means of graphs or lists of figures.

For this last purpose it is international practice[1] to state the percentages of five standard particle-size groups, the coarser ones separated by sifting, the finer by sedimentation in water. The finer particles are thus actually determined by their rate of settlement, not by their size; but we may reduce the definition of all five groups approximately to diameters as follows: gravel, above 2 mm.; coarse sand, above 0.2 mm.; fine sand, above 0.02 mm.; silt, above 0.002 mm.; and "clay", below 0.002 mm. "Clay" in this particular sense thus means nothing more than particles smaller than a certain limit. As has already been noted, it is unfortunate that a word implying so much more to the practical man has been chosen for this restricted purpose.

Consistence takes account of the hardness, softness, brittleness or toughness of soil lumps when dry, of greasiness, stickiness, tenacity or friability when moist, or compactness, looseness or porosity in the mass, of resistance to the spade or the ploughshare or the wheel. It is thus a very practical matter, and must have interested all workers on the land since first an ingenious nomad made his wife thrust a digging-stick into the ground for planting barley. Pigs, moles and ant-bears knew about it even before that. Words appreciative or abusive of soil consistence were probably amongst the earliest added to language after agriculture began. In English a farmer sums up the property by one or other of the words "heavy" (or "stiff"), "loamy" (or "mellow"), and "light". Consistence is, however, a complex character, and it is not easy to measure exactly the qualities that enter into it. The soil analyst has much progress yet to make in this department.

Structure relates to the size and shape of the compound units such as grains, crumbs, clods, and roughly recognizable solid geometrical figures, into which the individual particles and the organic matter of many soils are bound together in their natural state. It is revealed by the forms of the separate fragments into which a shovelful of fresh earth falls as it is tossed to the ground, or by the system of cracks that develops when an undisturbed mass of soil dries out. It can be best studied in well-weathered sections, such as the bank of a hillside road or the wall of an old pit.

Finally, *tilth* is the physical condition into which the topmost layer of a soil is brought by cultivation. Clearly it depends on all the other three properties and also on the treatment the soil has received. To be able to achieve the right kind of tilth at a given time of the year is always a major problem in any system of crop husbandry. In long-established systems on which generations of thought have been bestowed the problem has usually been solved for each soil type and each crop by accumulated experience, and the solution is flexible enough to meet any probable event of seasonable or unseasonable weather to best advantage. In pioneer agriculture, however, and in farming systems that still have only a generation or two of experience behind them, mistakes are easily made and may be costly. The black dust to which great tracts of ex-prairie soils have been reduced in North America is nowadays the standard example, but there are others familiar enough in East Africa, as on certain overcropped maize lands and clean-cultivated unshaded coffee plantations.

[1] Except in the United States, where a somewhat more elaborate grading, of long standing there, has remained current.

Can the operations of our tillage, then, be rationalized, for the avoidance of such mistakes? We must obviously know more of the interrelations of texture, consistence and structure in our East African soils if we are to retain command of their expression as tilth.

Older Ideas about Texture

Texture, the proportion of coarse and fine ultimate particles in a soil, is of course a property that has been decided for us, mainly by the nature of the parent rock but also by the stage this has reached in breaking down to soil and the manner in which the resulting grains and particles have been shifted and sorted (if at all) by the action of gravity, water and wind. Except by impeding further shifting and sorting, we cannot control it but must accept what we find. Being thus a fundamental datum, texture early received attention when soil began to be a subject of laboratory study. The methods of what became known as "mechanical analysis" (another question-begging term which I should like to see replaced by the more straightforward "texture analysis") were developed on soils of the north-temperate zone: mostly young soils formed since the Ice Age, often on glacial deposits, or derived from older sedimentary rocks whose materials at some time long distant were assembled under water. It was in terms of such soils, a restricted group, distinctive rather than representative amongst the infinity of the world's soil types, that the results of "mechanical analyses" were first examined for their relevance to what was known of actual mechanical properties.

For English soils and Continental or North American soils of similar origin it became apparent that the proportion of "clay" particles as reported by the analyst went hand in hand with the degree of stiffness experienced by the practical man in the field. Light soils consisted preponderantly of the sand fractions, and whenever the "clay" content went above 25 or 30 per cent, the sample could fairly be counted on to represent a heavy soil—strong land difficult to drain, needing considerable power for the draft of implements, not to be worked upon too soon after rain, and tending to afford a rough and cloddy tilth except under the most skilful management. Field behaviour could in fact be predicted from a mechanical analysis, with the aid also of information on such points as contents of organic matter and of lime carbonate.

Texture and consistence thus came to be regarded as closely correlated properties. Indeed, the first of the two words commonly did duty for both, and often, most regrettably, does so to-day. From about 1910 onwards advancing knowledge of clay as a chemical system led to some qualification of this too-simple view, but it remained substantially as the underlying assumption in textbook treatments of soil physics even in books published so lately as ten years ago. It played a large part in deciding survey methods in countries where organized soil survey was in progress.

Texture and Consistence in Tropical Soils

Let us now see how such an assumption works out on some representative East African soils. In Table 1 are given the textures of four pairs of samples, expressed in the customary manner by percentages of the four principal size grades; none of them contains an appreciable amount of gravel. In each pair the two sets of figures are seen to be closely similar. If it be added that none of the samples contains any lime carbonate or more than 4 per cent of organic matter, we should expect in each pair pretty

much the same working properties also. Actually, soils B, D, F and H are all friable and free-working. They readily part with excess water by drainage. Soils

TABLE 1

SOILS SIMILAR IN TEXTURE BUT DIFFERING IN CONSISTENCE

	Coarse Sand	Fine Sand	Silt	Clay
	%	%	%	%
COAST BELT NEAR TANGA				
A 1998 Kasela ..	49·0	14·5	1·4	30·4
B 1984 Kange ..	47·5	18·3	1·7	31·3
USAMBARA HIGHLAND				
C 600 Baga ..	23·8	19·7	13·4	37·0
D 931 Sangerawe	24·4	21·6	11·3	34·5
USAMBARA FOOTHILLS				
E 418 Tengeni ..	27·0	14·2	3·3	52·0
F 2236 Mlingano	29·6	11·3	3·6	54·5
KIAMBU				
G 11 Uplands ..	0·1	3·5	6·5	75·7
H 1418 Kiambu	1·6	3·7	10·5	75·8

A, E and G, on the contrary, are intractably stiff, almost untillable when dry and waterlogged when wet, while soil C, not so extreme, is nevertheless a strong sandy-clay of considerable tenacity. Thus of each pair one is a light or fairly light soil, the other is a heavy one. Texture by itself in these samples is evidently no guide to mechanical properties as they manifest themselves in the field.

The simple assumption that heaviness is proportional to "clay"-content holds good in fact only so long as we are dealing with the same kind of "clay". The surprising differences exemplified above between texturally similar samples are due to fundamental differences in the nature of their finest fractions. Such differences readily come to notice in tropical soils. In the classical soils of Britain, around which the familiar older textbooks were woven, they are less well marked and did not challenge attention.

THE NATURE OF "CLAY"

I have persisted with the inverted commas because so far I have used the word "clay" in the restricted sense of an item in a textural analysis, in which it denotes merely particles that fall below a certain limit of size. The materials included in this arbitrary group are not, however, a single kind of substance of universal properties. From soil to soil they may be chemically different bodies and be built to different patterns as crystalline minerals. From soil to soil also, and even from time to time in the same soil, these smallest particles may be in different states of individual and collective organization as complex colloidal systems, just as houses may differ in materials of construction and in plan, be differently furnished and be found detached from each other or connected up in streets and squares. (To make the analogy more perfect the collective organization should be thought of as mobile, like that of a houseboat town on a Chinese river.) Evidently we must know more about this "clay" complex than merely that the size of its ultimate grains is very small.

Clay (using the word now in a more general sense) results from the decomposition of the silicates of crystalline rocks. It may be a residue or it may be a re-compounded product. The chemical reactions that produced it may have followed their whole course in one place on a land surface during soil formation, or may have been resumed under water after the primary soil had been dispersed by erosion, or may have originated far underground. As an evolving constituent of a soil, a clay has been influenced by climate, acting through temperature

effects and through the amount and distribution of rain. It has been influenced by the chemical nature of the original silicates, and by the porosity of the decomposing mass. The topographic situation of the site has influenced it, according as surplus water has drained away freely, carrying off soluble products, or has tended to accumulate. The vegetation has influenced it—whether forest (and, if so, what type) or scrub, or heath, or grass, or the sparse cover of semi-arid country. It may be that man himself has been in occupation long enough to rank as a factor alongside these or in modification of them. In one or more of the respects mentioned the clay of to-day may in the past have had vicissitudes and a variety of experience, even to having been rebuilt temporarily into rock as a shale, or as the earthy ingredient in a limestone or the cementing agent in a sandstone. Finally, there is the question of maturity: how effectively have these various influences impressed themselves? Is the clay an end-product or is it an intermediate phase still evolving further?

It cannot yet be said that we understand the effects of all these possible factors in the genesis of a clay. But tropical soils form an especially favourable field for their observation, owing to the comparatively rapid pace of soil evolution in the tropics and the fact that certain extremes come under notice. With the aid of the advances made in European and American laboratories by specialists in the mineralogy and physical chemistry of clays, it becomes more and more possible to recognize in any given soil the kind of clay we are dealing with, and to limit expectations or guide practice accordingly.

At one end of the scale we have highly plastic clays characterized by minerals whose crystal structure and chemical composition confer a high capacity for base exchange and for water absorption. Such clays respond markedly by swelling and shrinkage to changes in moisture content, and in their cohesion and perviousness they are sensitive to changes in the chemical bases that they hold exchangeably, especially to whether the predominant base is lime or soda. Clays near this end of the range have a high content of combined silica and, as originally formed, of bases also. We look for them in circumstances where silica and bases have never been lost from the parent-rock silicates, or alternatively where there has been opportunity for recombination with silica-bearing and alkaline waters. For various reasons the soils in North-European latitudes have often originated under such conditions.

In the humid tropics the conditions for the formation of plastic high-silica clays are fulfilled more rarely. Decompositions are rapid, leaching is exhaustive; with a few exceptions due to local causes the clays present in soils with free drainage in high-rainfall areas are far gone in development towards the more inert types presently to be considered. From swampy sites in humid country there is a copious output of overflow water which keeps the accumulating sediment in a leached and acid state, and although some rebuilding to secondary clay can take place, highly plastic clays are not formed.

As country of lower rainfall and drier atmosphere is entered, both the residual and the secondary clays of this group are more likely to be found. The climate of the present day being, however, only one factor, and not necessarily the determining one, the nature of the parent material and of the topography and the weathering and erosion of past times also play a large part in deciding whether the clay fraction of a given soil is of the highly reactive, base-binding, shrinking-and-swelling kind,

or not. In semi-arid East Africa such clays are to be looked for in the fine-textured dark-coloured soils of open rolling plains such as the Athi and Kapiti Plains and the part of Masailand that lies between Arusha and Lake Manyara. Here the parent rocks are basic volcanics and the leaching-factor has been low. Other extensive occurrences are in the calcareous grey soils of inland-drainage basins such as the Wembere Steppe and the Lake Rukwa Trough, where drainages from the surrounding highlands and plateaux have accumulated and evaporated after bringing in dissolved bases and silica.

On a more local scale the same effect appears in the many *mbugas*[1] whose black, grey or dark brown soils are so familiar to motorists and to road engineers under a general title of opprobium: "black cotton soil". The notorious quality of earth roads on *mbuga* soils illustrates the characteristic qualities of this group of clays very well. When wet, a "black cotton soil," comparatively sandy-textured though it often is, is highly plastic and offers neither resistance to deformation by wheel-pressure nor friction against spin. It drains badly, being almost impervious once swelling has closed the pores. When drying after being kneaded under traffic, it sets into ruts that are first tough, then iron-hard. The change from the plastic to the tough state is brought about over a comparatively small range of actual moisture-content, and proceeds rapidly once drying has begun. If the wet soil has not been kneaded it retains its natural structure and splits into its structural units again, as it dries, by the reopening of cracks. It is clear that in cultivation such a soil needs very careful and well-timed handling, at a certain state of moistness only, if a reasonably good tilth is to be obtained.

There are also soils of quite coarse texture in which a little clay of this kind goes a long way in influencing mechanical properties, particularly in rendering sloping ground liable to destructive erosion. Examples occur in areas of badlands, as in the neighbourhood of Kondoa Irangi, and in certain unstable cuttings through the Pugu Hills on the Central Railway in Tanganyika. The conjunction of a coarse-sandy texture with a swelling-and-shrinking type of clay allows a porridge-like consistence to be developed at any surface that is wetted by heavy rain after drought; and if the slope and the bareness of the ground permit, the porridge rolls downhill, to be finally dissipated into clean sand and turbid floodwater.

The presence of a clay of this kind in soils not extremely coarse in texture reveals itself in dry weather in characteristic structural cracks. Sometimes the soil mass is split deeply into prisms and columns parted by fissures wide enough to thrust the hand into; sometimes it is divided into smaller angular units regularly packed. It will be seen later in this discussion that the structural pattern is determined not only by the nature of the clay and its quantity, but also by the amount of humus present and by the lime-status of both the clay and the humus. In general, soils containing high-silica reactive clay rank as *heavy* soils, within a given textural group. If not acid they are potentially very fertile, but often lie uncultivated because of their difficult mechanical properties and poor drainage. Their most usual natural vegetation in East Africa is grass of a tufted and erect habit, with or without an open scattered stand of acacia, frequently one or other of the gall-acacias or the large umbrella-thorn, *Acacia spirocarpa*.

[1] *Mbuga*, an open, grassy and seasonally wet lowland.

At the other end of the scale we have inert materials akin to china-clay, which bestow hardly any cohesion or base-binding power and give little sign of their presence in a soil except mere fineness of texture. Sandy soils containing up to 25 or 30 per cent of such clay are known which are hardly modified at all from a character of extreme lightness. Such are a widespread group of pale-coloured soils derived indirectly from granite and found under deciduous savanna woodland or closed deciduous thicket in the Central Province of Tanganyika. The same inert type of clay probably contributes much to the fine texture, but almost nothing to the total stiffness and reactivity, of the Kiambu red loam and its group in Kenya. Unless other clay types are simultaneously present, or there is sufficient organic matter in the right condition, the soil is structureless. It may cohere in irregular lumps on drying, but such lumps are brittle and easily powder down to dust.

Then, beyond the range of the true silicate clays, and doubtfully to be admitted under the name clay at all, are the sesquioxides, the oxides of aluminium and (ferric) iron, which bulk largely in the laterized red and yellow-brown earths of humid forested regions in the tropics and of some humid plateau grasslands. They are breakdown products of the silicate clays, from which silica has been removed. Like the inert true clays just considered, they contribute little to base-absorbing power or to stickiness, and soils containing even large amounts of them drain freely and remain friable.[1] They have their own qualities of weak cohesion which are manifested, in soils containing much material of this kind, as a fine porous structure not unlike the weave of a rough towel. A well-weathered section of a sesquioxide soil shows the lines of parting of what might be large ill-defined pillar-like clods, but on digging the clods crumble, and if moist fall down to little more than a coarse meal.

Amongst materials that in particular soils come into the "clay" fraction must also be mentioned very finely abraded quartz dust, and amorphous redeposited silica in uncombined form. Certain crystalline secondary minerals such as talc also play a small part.

Soils not characterized to an extreme by any one of these main kinds of clay, but containing two or more of them simultaneously or intermediate forms not so well defined, are of course in a majority in cultivated lands. Only here and there does the cultivator deliberately select extremes amongst soil types, and then for some special crop or special farming system. Mixed agriculture flourishes best on soils that display a blend of mechanical properties imparted by more than one type of clay-substance. The blend is the result to date of various successive or concurrent processes of soil formation that have been at work on the given parent materials. Alternatively, it is desirable that a range of different soils, with its corresponding variety of clay types, shall be found within a short distance, so that a holding of reasonable size shall include all. This is often the state of affairs in undulating country where hill-slopes alternate with broad bottom-lands. Two East African examples may be cited: the country of the Wasukuma, to the south of Speke Gulf on Lake Victoria, and that of the Wabondei in the foothills of Usambara. In such districts success in land-utilization requires a suitable adaptation of crops and their tillages to the

[1] For a description of a typical sesquioxidic soil as found under forest in East Usambara, see the previous Essay in this series, *E. Afr. Agr. J.*, Vol. III, pp. 11-16, 1937.

different soils, and especially to the different sets of physical conditions that go with clay characters.

A particular case of mixture of clay types must be briefly referred to as of common occurrence in tropical soils. The "clay" fraction of most well-drained soils derived directly from rocks containing iron-bearing minerals consists to some extent of ferric oxide in free condition. Especially is this true of soils that have evolved under equable and moderate to high temperatures, as in the tropics. In the warmer situations, or alternatively where there is a season of deeply penetrating drought, the presence of ferric oxide is shown by a red colour; but it may equally be present in hydrated condition in yellow, brown and chocolate soils. The statement applies even though the clay of such soils does not happen to be mainly of a sesquioxidic type and may contain no free alumina. The presence of a proportion of free iron oxide in the "clay" fraction partly accounts for the relatively free-working properties of tropical (well-drained) soils in general within their textural groups.

The Part Played by Humus

The amount of clay and its nature, considered together, thus in a general way accounts for why one soil is stiff, another is moderately friable and a third is hardly held together at all. Twenty-five per cent of true plastic clay will make a soil effectively heavier than seventy-five per cent of fine material of less reactive type. The colloidal part of a soil, i.e. the sticky part (Greek *kolla,* glue), is not, however, only the clay. It is also the humus. Humus, like clay, has powers of absorption of water and of the chemical bases. It displays a very marked shrinkage as its water content falls. It becomes the seat of acidity when the basis it holds are washed out by the long-continued action of percolating rain water. These properties it possesses in greater degree per unit weight than clay, even than the most highly reactive of the clays. According to estimates made on European soils, the maximum base-binding capacity per unit of humus is somewhere about five times as great as that per unit of the clay accompanying it, and where, as often in East Africa, a soil is fine-textured but friable, the ratio is likely to be higher. A small increase or decrease in humus-content therefore has a relatively large effect on the total manifestation of colloid properties.

Now the cohesive or structure-forming activity of both kinds of colloid depends on this base-binding capacity. Recently a very clear picture has been suggested[1] of the way in which electrical forces link together the colloid particles, which are electro-negative, through the basic ions which are electro-positive and the water molecules which are "dipoles". This picture does not yet lead to an explanation of the sizes and shapes of the resulting compound structural fragments that are revealed as the moist soil dries, but one important difference between the effects of clay colloid and of humus is a matter of common observation. Clay particles, if of the reactive kind, by themselves tend to form dense compact aggregates which are soapy when moist and which dry hard. These are the familiar clods of a clay subsoil; they vary in size and shape and in toughness or brittleness according as lime or magnesia or soda predominates amongst the active bases, and also according to the proportion of silt and sand particles included. Humus, on the other hand, renders the structural units porous and cellular; they become crumbs. The

[1] By E. W. Russell of the Rothamsted Experimental Station.

presence of humus therefore tends to modify either extreme of a purely clay-caused consistence in the direction of mellowness. A merely friable mineral soil, plus humus, becomes a loam; a stiff clay is puffed out and becomes a clay-loam; a sand or a fine-textured sesquioxidic material is bound together and becomes a light loam. In all three cases a satisfactory tilth becomes possible, and with it are achieved greatly prized agricultural advantages in such matters as ease of cultivation, suitable seed-bed, efficient incorporation of manures, absorption of rain, resistance to shifting by water, admission of air to roots, and so on.

We have here the proper and original usage of the word *loam*, in which it denotes not a particular textural class but a certain kind of consistence and structure, a quality of mellow crumbliness imparted by a sufficiency of lime-saturated humus.

Structure under Different Vegetation Types

A loamy structure, then, in whatever textural grade a soil may fall, is the ideal. It is not by any means universally provided by nature in virgin soils.

Forest land sometimes possesses the desired structure in its top soil, but only when leaching has not been excessive. The wetter types of East African evergreen forest at moderate elevations usually have a top soil that is revealed as mealy rather than loamy when once the interlacing mass of living roots and still-organized debris has been worked out by the early cultivations. At higher altitudes, where lower temperatures impede decay, the structure of the humus layer becomes peaty or waxy, while that of the mineral soil just below it becomes powdery. The lime-status both of clay-colloid and of humus-colloid is kept low by frequent and prolonged rinsing with rain water, and one of the conditions of good crumb formation is not fulfilled. What under leaf litter and moist shade has appeared to the land prospector to be a "rich forest loam" falls short of expectations when brought under tillage; such structure as exists is not of a stable kind and quickly breaks down. Under lighter rainfalls, or when the soil's parent material was rich in bases to start with and has been slow to show the effects of leaching, humus comparatively rich in lime may accumulate in forest, and the result is a true loam. Examples of such forest loams, of dark brown colour and of excellent structure, occur on Kilimanjaro between the mist-forest belt and the upper edge of the *Combretum* savanna belt. Some localities in the less humid parts of the West Usambara highland have similar forest loams, coarse in texture through being derived from gneiss instead of lava. The coffee areas of Kiambu and Ruiru seem to have had topsoils of good structure originally, under the Kikuyu evergreen forest and its moderate rainfall of 1,000-1,250 mm. (40-50 inches).

The high temperatures of tropical lowlands favour decomposition rather than retention of humus, but the right conditions for forest loam formation sometimes occur in conjunction: shade, humidity, a low leaching factor, a parent material providing sufficient lime and a circulation of mineral elements through trees or shrubs. Thus the shallow chocolate soils found under coastal thicket on coral rock are true loams; they will be familiar to suburban gardeners at Mombasa and Tanga (Ras Kazoni) and at Dar es Salaam (Oyster Bay), unless excessive zeal in watering, together with exposure, has spoilt them. They are utilized in a form of shifting cultivation in the extensive "Wanda" country in the south of Zanzibar Island. There are probably considerable areas of such chocolate loams in reserve under the dense secondary bush

that has taken possession of the former slave-worked cultivations of the Kenya coast belt. Further inland, in Tanganyika, there are examples of good loams both on sedimentary rocks and on Basement Complex gneiss under evergreen light forests of the daisy-flowered tree *Brachylaena Hutchinsii*. A final example that may be mentioned is the topsoil of some of the abandoned 25-30 year old plantations of Ceara rubber, which were usually sited on good red earths of middle texture in areas of medium rainfall and which by a generation of neglect have grown into a form of forest.

Loamy structures are also characteristic of the soils of non-sour and non-swampy grasslands, particularly when the forms a close turf. Here the humus has accumulated by a somewhat different process; not by leaf-fall upon the surface as in forests, but by implantation of residues in the soil itself by the decay of many successive ephemeral root-systems of grasses and herbs. Everyone is familiar with the way the soil under such a sod hangs together in crisp, firm, yet porous crumbs. It is this property, so long as it lasts, that contributes to make a ploughed grassland of the prairie type so attractive to the wheat farmer. The same property is one of the several advantages sought when land is put up into temporary ley in rotation with arable crops, as in increasingly being done wherever possible in the mixed farming districts of the Rift Valley in Kenya. Similarly, it is achieved under elephant grass on the red-brown soils of Mengo, Uganda, and contributes to the benefits of planting temporarily unused land with this grass after a period under food crops and cotton.

The loamy structure is less commonly found under open stands of grass of tufted habit, such as occupy immense areas in Tanganyika and Northern Rhodesia under the light and seasonal shade of *miombo*[1] woodland. Amongst tufted erect grasses the conditions of soil exposure and surface soil temperature are more akin to those between the spaced plants of a wheatfield. In *miombo*, also, the soils are usually leached and acid in reaction; but on the sides of rocky kopjes in such country, where the conditions of shade and exposure are similar but surfaces of fresh silicate rock are contributing currently to the maintenance of soil's lime status, the true loam structure is again found. The significance of lime status is illustrated further by the sour grasslands of the sandstone ridges of Bukoba, whose soils under their 1,900 mm. (75 inches) of rainfall have almost no structural cohesion, rich though they are in organic matter. The humus and clay-complex being acid, in this case with the added disadvantage that the clay is of sesquioxidic type, the crumb-forming mechanisms are not in operation. Finally, in regard to grassland, it is a general observation that the dark-coloured heavy soils of low-lying basins and grassy seasonal swamps are found at their structural worst when acid, or when, though neutral in reaction, they contain no lime carbonate in the upper horizons. When lime is plentiful right to the surface, their hardness in the dry state is mollified by the development of a fine meshwork of cracks.

Loss of Structure in Cultivation

In certain favourable circumstances, then, natural processes have been at work

[1] *Miombo*, a mixed open woodland of slender, spreading, mostly pinnate-leaved trees of a number of species, with *Isoberlinia globiflora* and the genus *Brachystegia* as dominants; leafless annually during four or five rainless months and towards the end of that period usually swept by fire.

in the virgin soil that make for the ready production of a good loamy tilth when the land is broken for agriculture. Many soils will actually be in a less favourable state, either as virgin land of poorer type or as land originally in good order structurally but deteriorated through errors of handling; but for convenience we may take such an idea loam as the starting point. We know that two at least of the factors of structure are amongst the more susceptible, or adjustable, of soil properties, namely the amount of humus-colloid and the degree of saturation of the total colloid with bases, especially its saturation with lime. What then happens to our ideal loam when the forest is felled or the grassland broken, and season succeeds season under arable cropping?

In certain more permanent respects the conditions are unaltered. Amongst these there are the broad influences of climate, that is to say "standard climate" as recorded by the instruments in a screen. It may be that we should allow for the well-known change for the worse in the annual weather that sets in after the pioneer has begun to take records. Apart from this misfortune, however, which is common to most newly settled districts, clearing for cultivation has immediate effects on the climatic experiences of the soil itself. They may be summarized thus: greater daily extremes of temperature, exposure to full sunlight, severe drying of the topmost spit of soil, exposure to wind, exposure to the direct beat of falling rain. Besides these climatic effects there are the mechanical effects of the acts of tillage, which on the whole tend to break and powder the structural aggregates rather than to rebuild them. The point of balance of soil organic matter is altered, against accumulation and in favour of chemical breakdown. The restorative circulation of bases through forest trees or other natural plant cover is interrupted and the rate of loss by leaching during rainy weather is much increased. There is some removal of lime and potash in the harvested crop.

Most of the tendencies in an arable soil, cropped continually without return, are thus towards loss of loaminess, for the elements of stability of crumb-structure, especially humus and lime, are affected at many points, and always adversely.

Structure-maintenance as a Definite Policy

The tropical agriculturist and his advisers have heard much about replenishing humus, and since the Howardian rationalization of the rubbish-heap they are increasingly learning how to do it. Here is the same policy presented in the guise of rationalized soil mechanics. The question of liming has usually been looked at more narrowly. It has been approached rather from the angle of the field experiment or of the demonstrable need for liming some particular crop for plant-physiological reasons affecting growth and yield. By such a test, and on a short view, liming is often uneconomic on tropical crops, especially when cheap lime is hard to come by. For certain crops such as tea, liming must, we are told, definitely be avoided for good reasons of the plant-physiological kind. Such special crops apart, I recommend fresh attention to the subject of liming in East Africa, in its due conjunction with humus-manufacture and on its long-term merits as a means of preserving soil structure; of preserving it, that is, if happily it already exists; of building it up against contrary environmental tendencies, if it does not.

From time to time in the long history of agriculture in the British Isles, liming has in turn been fashionable and in turn neglected. Always the need for it has again been felt by those who value having their land "in good heart", and arrears

have been made up on a general scale almost irrespective of particular crops or particular soil types. This has happened under a climate that in many respects is much less hard on soil structure than are our tropical climates, whether humid or semi-arid. The British climate also has an invaluable structure-restoring element which we altogether lack, namely winter frost. Frost, by the pressures it exerts within a freezing soil and their release at thawing, reconstructs the units of soil structure and at the same time ensures that they are internally shattered and porous. It also restores swelling power to humus, which lost that power as it dried during the preceding summer. In East Africa, not even at the dizzy heights of Timboroa[1] are frosts experienced that will do what the British arable farmer has always relied upon to have done for him as an annual event.

The East African cultivator is thus under obligation to do for his land not only the tropical equivalent of all that his British colleague does in this branch of soil management, but a good deal more; for in these latitudes nature withholds help and in one way or another is destructive of exposed soils all the year round. At his least ambitious level as an agriculturist, man is but an agent of these destructive forces, an earth-scratching animal. In that capacity he deserves the use of no more land than is required for a burrow. On any higher claim he must put himself in control and see to it that natural forces work for him constructively. In the field of tropical soil mechanics there is ample scope for improved management in this sense.

[1] Timboroa, an arable-farming district of Kenya, near the equator, at 9,000 feet above sea-level.

The Production of Native Beer in Uganda

By G. B. MASEFIELD, *B.A. (Oxon), A.I.C.T.A., Agricultural Officer, Department of Agriculture, Uganda Protectorate.*

The production of beer plays such a large part in the economy of native agriculture in Uganda that no apology is needed for bringing into the light a subject about which little or no published information appears to exist. In some parts of Uganda, as will be shown below, the acreage under the beer crop actually exceeds that under any other single crop.

Uganda may be divided agriculturally into two zones, that in which plantains grow and are the staple food of the people, and that in which plantains do not grow satisfactorily and the people are consequently grain-eaters. The two areas are much interwoven, but the chief concentration of the plantain-eaters is in the centre and south of the Protectorate, and of the grain-eaters in the north and east. Corresponding to these two types of diet are the two main types of beer; the first is made from plantain juice with the addition of a little sorghum, the second from sorghum alone. To make clear the way in which these types of beer are made, it will be best to describe their production in a typical area of each zone.

BEER MADE FROM PLANTAINS AND SORGHUM

The making of this type of beer will be described as it is practised in Buganda Province, the most typical area. In this province the family farm centres round the *lusuku* or plantain garden, in which various types of plantains are grown intermixed; the three main types being boiling plantains (known in Luganda as *matoke*), roasting plantains (*gonja*), and beer plantains (*mbidde*). Beer is normally made from *mbidde* only, except in Mawokota county, where a local preference exists for mixing *gonja* with the *mbidde*.

While carrying out some village agricultural surveys in Masaka District in 1936, the opportunity was taken of finding out the proportions in which these different types are planted in the average plantain garden. Accordingly counts were made of the number of stools of the three main types in three plantain gardens, and the result showed that of the total number of plantains 61 per cent were *matoke*, 31 per cent *mbidde*, and 7 per cent *gonja*. As the average area of plantains per holding was found in these surveys to be 1.8 acres, this will give some idea of the tremendous acreage which is under beer plantains alone.

The method of making beer is as follows: The bunches of *mbidde* are first cut. Each bunch is then divided into two and placed in the sun for two to three hours. They are then placed in a deep circular pit which has been previously dug in the *lusuku*, surrounded and covered with plantain leaves, and the top is finally covered over with earth. Here the plantains are left to continue ripening or fermenting for three days, after which the earth is removed; after three more days, they are taken out, peeled, and placed in what are generally known as "beer canoes" (large wooden vessels hollowed out of tree trunks and having the shape and appearance of a small canoe). As they are placed in the canoe they are mixed with grass, usually of the kind known as *lusenke* (*Imperata* sp.). A man then stands on the top of the plantains in the canoe and tramples them to extract the juice. It is to be noted that in Buganda beer-making is generally carried on by men, although there is no traditional objection to women and girls

taking part; but in this process of trampling the services of a skilled man are regarded as essential, as it is said that a strong and skilled man can accomplish it much more quickly and thoroughly.

When the trampling is finished, the juice which has been expressed from the plantains is poured into jars. The grass in the canoe, which contains further traces of juice, is washed with a little water, and this weaker extract is poured into other jars. A second canoe has meanwhile been cleaned, and the two extracts are now poured together into this.

While this has been going on, sorghum has been roasted and ground, and the flour is now added to the plantain juice, the proportions being well known to the makers, and usually just sufficient to turn the mixture brown (about one basketful of sorghum flour to a canoe of juice will accomplish this). When mixing is completed, the canoe is covered with plantain leaves and grass, and the mixture left for twelve hours or longer to ferment. The beer is then filtered through *lusenke* grass into jars, and is ready for drinking.

Variations

Many variations of the above method are practised, of which only a few need be described here:—

(1) The "unfermented beer," known in Luganda as *omubisi,* consists of the plantain juice without addition of sorghum flour, and not left to ferment. It is used as a refreshing drink.

(2) Another type of beer is made with the addition of bracts from the flower-bud of the plantain, known in Luganda as *empumumpu.* These produce a sappy extract, and it is said that the resulting decoction has a bad effect upon the system.

(3) In Mawokota county, where *gonja* are mixed with *mbidde,* the plantains, instead of being placed in a pit, are supported on a kind of net suspended between poles, and under which a fire is lit, so that the "ripening" process is achieved in a different way.

(4) In some parts of the country (but not usually in Buganda) honey is mixed with the beer before fermentation, and makes a very potent drink which in some cases is prohibited by the Native Administration.

(5) Beer may also be made from the pure plantain juice only, without the addition of the washings from the grass in the canoe. This is known in Luganda as *amawa,* and is also very strong.

Beer made from Sorghum Alone

The method of preparing this will be described as it is practised in Kigezi District. Here again the acreage grown for beer-making purposes is very large. In parts of the district a few plantains are grown, but almost all the beer is made from sorghum alone. In three village agricultural surveys carried out during 1936 the acreages per taxpayer under the chief crops were found to be as follows:—

	Acres.
Sorghum	0.722
Maize, beans and peas (mixed cropping)	0.671
Sweet potatoes	0.495
Plantains	0.292
Eleusine	0.185
Coffee	0.077
Tobacco	0.013
English potatoes	0.008
Miscellaneous	0.006
Total ..	2.469

Sorghum easily tops the list of crops in this table, and as it is only used to a very small extent as a food the amount which goes into beer-making is very large.

The method of making beer is as follows: Well-dried sorghum is first mixed

with wood ash, the mixture being slightly moistened with water. It is then put in a grass bundle and suspended in a stream to steep for twelve hours. On removal, the bundle is opened and spread out in the kraal, when germination takes place. The germinated grain is thoroughly sun-dried, a small quantity of it is now taken and ground, and the flour made into a paste with boiling water. This paste is left to ferment for three days, then boiled, and left for another three days. A little more flour is then added, followed by one more day's fermentation.

Meanwhile, the bulk of the sorghum has been ground, and the flour (or malt) is now placed in a canoe. To this boiling water is added, and the mixture stirred into a dough, after which a larger quantity of cold water is added. Then a number of jars are filled with the mixture, and into each jar is poured about a cupful of the "starter" prepared as described above. The whole is then left to ferment for one day, and the beer is ready for drinking.

In this district, beer-making is only carried out by women and girls.

Variations

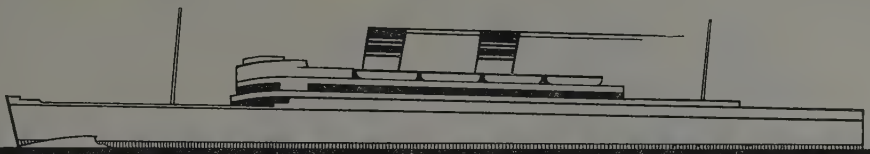
(1) An "unfermented beer" is made. To prepare this, germinated sorghum is ground; the flour is mixed in cold water and boiled. After standing overnight, it is ready for use.

(2) In times of scarcity of sorghum, beer may be made in the same way from finger millet (*Eleusine coracana*), or from a mixture of sorghum and finger millet and maize.

Uses of Beer

Beer of either variety has many of the properties of a food as well as of a drink. Beer parties may sometimes last for a week, during which a family will take no other nourishment and do not seem to feel the need of food. Beer is also commonly fed to children and even the youngest babies.

The subject of beer-making opens up many aspects which cannot be considered here, since they are not of agricultural importance. Many of the oldest customs and traditions of the people are connected with the making and drinking of beer. Subjects which are worthy of special study are: The methods of making beer for special occasions, such as marriages and funerals; the large vocabulary of words in Luganda and other native languages connected with beer-making and drinking; and the legislation passed by the Protectorate Government and the various Native Administrations to control the manufacture and use of beer. Beer also formerly had a considerable economic importance, being used especially in the payment of the bride-purchase, and in the payment of the form of rent known in Buganda as *Nvujjo*. In these and other uses, however, it is now becoming or has become obsolete.



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The Effect of Certain Factors on the Production Cost of Coffee and on Estate Profits

By J. F. PERKINS, *Kitale, Kenya Colony.*

GENERAL

The desirability of keeping farming cost accounts has been repeatedly emphasized by writers on agricultural economics. Yet one finds that many coffee planters either keep no books at all, or else keep their accounts in such a form that very little useful information can be extracted from them. Even those who maintain a proper system of book-keeping sometimes fail to appreciate the many ways in which the resulting figures may be made to yield valuable information on the economic aspects of estate policy.

The traditional theory that the planter's time is better spent in the field than in the office is clearly liable to exaggeration. One feels that the technical problems of coffee planting are in some cases given rather a disproportionately large amount of attention as compared with its economic aspects, whereas the latter, especially in times of low price levels and scanty profits, are really of fundamental importance to all who are concerned with the prosperity of the coffee planting industry.

The keeping of plantation cost accounts, once a simple and adequate system has been formulated, is not nearly such an arduous task as is commonly supposed. The importance of simplicity is paramount, and in practice it is found that the daily routine allocations can all be carried out after a week or two's training by any native clerk who can add and can read and write Ki-Swahili.

But cost accounting is not, from the planter's point of view, an end in itself; and time and diligence expended on it are unproductive unless proper analyses are subsequently made of the results obtained, appropriate deductions drawn, and suitable action taken.

It is not the intention to discuss here the various methods of estate cost accounting. Anyone interested will almost certainly have read at any rate the article by Mr. V. Liversage which appeared in this Journal (Volume I, No. 2, pp. 154-161, 1935). It is, however, intended to give below an indication of some of the general deductions which may be drawn from an analysis of the results of a simple costing system; and to show in what way, and to what extent, various factors such as acreage, yield, and so on, may affect the cost of producing coffee and the economic stability of the estate.

Cost accounts have now been kept over a period of three years on a coffee estate on Mount Elgon. For various reasons the actual figures themselves will probably not be applicable to estates in other coffee districts, where entirely different plantation methods may be practised. It is felt, however, that certain useful generalizations can be drawn from them, and they are used, by way of example, as a basis for the discussion following.

It is hoped that planters whose costs differ widely from those adopted here, and who have cost accounts available, will substitute their own basic figures for those given in the present calculations and draw their own conclusions. Those who keep no cost accounts of their own might well accept the general trend of the argument, but should apply the numerical results with discretion.

The problems discussed below are considered solely from the view-point of the private coffee planter. It will probably be only too obvious that the writer

is not properly conversant with the methods of professional accountancy; moreover lack of personal experience precludes discussion of many of the problems peculiar to the Eastern coffee districts, and to the organization of large estates, or groups of estates, on company lines.

Cost of Production of Coffee—General Considerations

In order to avoid all unnecessary complications we shall confine ourselves throughout to the consideration of the simplest possible case, that of an estate which produces only coffee; the remarks and conclusions which follow apply strictly only to such cases, and must be interpreted with care if applied to estates which produce more than one saleable product.

Further, only the problem of the annual recurrent production costs of coffee on an estate already in production is taken into consideration at the moment. The capital and development costs necessary to bring an estate into bearing must be regarded as a separate problem—one of comparatively minor importance to existing estates and one which depends to such an overwhelming degree on individual conditions as to be virtually incapable of any general solution.

Although a general appreciation of the principles of cost accounting is hereafter assumed, a brief note on the form in which the costs are here set out may be desirable.

For the purposes of cost allocations the estate is divided into sections, each section covering a particular plantation operation, with one or more additional sections to cover the items usually referred to as "overheads", thus:—

TABLE 1

A. Non-recurrent (Capital) Charges—
- 0. General capital operations (carried out under individual Job Nos.).
- 1. Ploughing, harrowing, and preparation of land.
- 2. Lining out, holing and planting.
- 3. Replanting misses.
- 4. Coffee nursery.
- 5. Terracing, draining and wash-stopping.

B. Maintenance Costs—Independent of yield per acre—
- 6. Cultivation and weeding.
- 7. Couch and headlands.
- 8. Pruning and handling of coffee, shade and shelter.
- 9. Pest control.

C. Optional Treatments—Aiming at increased yields—
- 10. Green manures and cover crops.
- 11. Fertilizing and dunging.
- 12. Mulching.
- 13. Irrigation.

D. Costs Proportional to Tonnage Handled
- 14. Picking and conveying crop to factory.
- 15. Factory work.
- 16. Transport to mill.
- 17. Bags, milling, transport to station, etc.

E. General Estate Charges (Recurrent)—
- 18. General maintenance.
- 19. Management.
- 20. Factory, implements and tools.

This schedule is merely given as an example, and can of course be simplified or elaborated to almost any extent to suit individual tastes and requirements, *so long as the separate identity of the five groups A, B, C, D and E is not destroyed.*

A very simple system for the daily allocation of boy-days, ox-days, lorry- and tractor-hours, etc., to their appropriate section is in operation. This work, together with the keeping of labour tickets and routine records, is done by an inexpensive native clerk under occasional supervision by the manager. The allocation of purchases, petty cash, etc., is carried out by the manager at the end of the month.

At the end of the financial year a sheet is prepared, summarizing the total expenditure on the estate under each of the above heads. Table II reproduces, in a somewhat condensed form, one of the

annual cost summaries of this estate. It is included, without further comment, simply as an example of the way such a cost summary may be set out so as to show the essential items in a simple and easily assimilable form.

The first group, A, consists of operations regarded as capital, or at any rate non-recurrent charges, are omitted from consideration here.

The second group, B, are generally agreed to be essential operations, which no planter can reasonably neglect to carry out over his whole coffee acreage, and whose cost is therefore more or less directly proportional to the planted acreage of the estate. Their cost bears no relationship to the tonnage of coffee produced.

The third group, C, are optional, extra treatments which can be applied or withheld as conditions warrant. They imply the expectation of increased crops; they should only be carried out when they are economically justifiable; and they are usually not all carried out over the whole acreage of the plantation every year. Their cost is directly proportional to the acreage treated, and is not itself affected by the crop which results. No hard and fast distinction between groups B and C is implied; it is obvious that

1935 TABLE II

	Boy-days	Ox-days	Cost of boy-days at 23·8 c.	Cost of ox-days at 5·0 c.	Total labour cost	Additional costs		Total cost	Acres treated	Cost per acre
B.			*Sh.*	*Sh.*	*Sh.*		*Sh.*	*Sh.*		*Sh. cts.*
6. Cultivation and weeding	4,908	2,256	1,170	112	1,282	.. ..	..	1,282	194	6 60
7. Couch and headlands	618	112	147	6	153	.. ..	..	153	194	79
8. Pruning and handling	276	—	66	—	66	.. ..	..	66	108	61
										7 90
9. Pest control	142	—	34	—	34	Cutworm shields	163	197	20	9 90[1]
C.										
10. Green manures	397	72	95	4	99	Seed	27	126	35	3 60
11. Fertilizing and dunging	624	1,136	148	57	205	Guano	895	1,100	55	20 00
12. Mulching	257	—	61	—	61	.. ..	..	61	14	4 35
13. Irrigation	71	—	17	—	17	.. ..	..	17	6	2 80
										30 75
									Tons	Cost per ton
D.							*Sh.*			*Sh. cts.*
14. Picking	2,400	704	572	35	607	Casual labour	595	1,202	19·7	62 00
15. Factory work	712	—	170	—	170	Fuel oil and lubs	794	964	19·7	49 00
16. Transport to mill	66	352	16	18	34	Lorry hours	210	244	19·7	12 40
17. Milling, etc.	—	—	—	—	—	Bags, milling charges, transport to Kitale, etc.	1,514	1,514	19·7	77 00
	10,471	4,632	2,496	232	2,728		4,198	6,926	—	200 40
										Cost per annum
							Sh.			£
18. General maintenance	—	—	—	—	—	Balance of Account	5,820	—	—	291
19. Management	—	—	—	—	—	Ditto	4,680	—	—	234
20. Factory, implements, tools	—	—	—	—	—	Ditto	2,320	—	—	116
							Sh. 12,820		£	641

[1] In this case a non-recurrent charge.

what is regarded as an optional treatment in one district may be an essential in another.

The fourth group, D, are essential operations whose cost is directly proportional only to the tonnage of the crop handled, and bears no direct relationship, except in extreme cases, to the acreage from which the crop was obtained.

The fifth group, E, are overhead charges, the magnitude of which varies directly neither with acreage nor with crop, but depends to a major extent on the circumstances of each individual estate. For a given estate these costs depend more on the time factor than anything else, and are most conveniently expressed in the form £*z* per annum.

Now, although it is quite clear that the only cost figure of ultimate importance is the total cost per ton of coffee produced, it is essential, *in the first instance,* that operational costs which vary with a particular factor should be expressed in terms of that factor, i.e. B and C costs should always be expressed primarily in the form Sh. *x* per acre, D costs as Sh. *y* per ton, and E costs as £*z* per annum.

It is only by treating each group of operational costs separately, and expressing them in this manner, that (*a*) any kind of useful relation can be found between the costs of different estates, and between one season and another, and (*b*) any general idea can be obtained of the effect of such variable factors as acreage and yield per acre on the cost of production of coffee.

An example will make this clear. Our cost of pruning and handling is about Sh. 2 per acre per annum. This is a basic figure which is affected practically speaking only by known factors such as the methods and technique of the manager, the current wage rate, previous climatic conditions, and so on. This figure can be compared directly with similar figures for pruning cost per acre obtained in other years or on other estates; and it will probably be found that this cost does not vary much between one efficiently managed estate and another in the same district.

The derived figure, pruning cost per ton of coffee, is obtained by dividing the basic figure, pruning cost per acre, by a figure denoting tons of coffee produced per acre. But this arithmetical conversion has introduced a new variable—yield—to confuse the issue. For although yield can of course be affected in some measure by pruning technique, it can also be affected by an enormous number of other circumstances, some of which may be under the control of the manager, but many of which are not.

If our plantation during one season produces 8 cwt. per acre, and during another season, owing say to a severe attack of Coffee Berry Disease, only 2 cwt. per acre, our pruning costs, though remaining constant at Sh. 2 per acre, will have risen from Sh. 5 to Sh. 20 when calculated per ton of coffee produced. And the expression of our pruning costs in their derived (per ton) form, instead of in their basic (per acre) form, has in this instance, owing to the incidence of a disease which is probably quite unrelated to the pruning methods used, given an entirely misleading comparison between the efficiency of our pruning technique in the two years. A serious difference is shown where none really exists.

This point of view naturally has its limitations. It may be determined experimentally that extra expenditure on handling produces, *per se,* an economic return in the form of increased crop; in which case the figure denoting pruning cost per ton may possibly be a more reliable index of management efficiency than pruning cost per acre. But yield is

affected by such an enormous number of factors, known and unknown, that such a case is the exception rather than the rule, and must usually be discounted.

The same argument applies with equal force to every other cost group; and it becomes clear that only by analysing operation costs in detail, and in terms of the factor to which they are proportional, can any lucid comparison be made between the economic status of different estates, districts, seasons, methods of management, and so on.

Liversage has shown (Kenya Dept. of Agriculture Bulletin No. 9 of 1932) how widely and apparently inconsequently, even within the confines of a comparatively small and highly developed district, operation costs, as well as total production costs, may vary. If these costs are expressed per ton of coffee produced one reason is obvious. The process of adding together certain cost figures which are proportional to acreage, certain figures which are proportional to tonnage, and certain figures which are a function of time, and then dividing by the tonnage of crop produced, cannot be expected to give a consistent figure, unless some constant relation exists between yield per acre and yield per annum, which naturally is not so in a number of heterogeneous estates.

In short there is not, and cannot be, any figure which represents with any general applicability the cost of production of coffee. And the various figures which have been suggested from time to time are of necessity based on such very broad assumptions that they cannot be expected to hold even approximately in any individual case.

The present object is therefore not to attempt to evaluate the cost of producing coffee, but, by analysing in detail the various items which go to make it up, to show what cost might be expected under certain circumstances, and in what manner and to what extent the alteration of certain controllable conditions are likely to affect this cost and the resulting economic equilibrium of the estate.

Cost of Production of Coffee—Particular Considerations

Average cost figures obtained on this estate on Mount Elgon during the past three years have been taken as a basis in all the discussions given below, mainly on the grounds that actual cost figures of some sort are more interesting than purely hypothetical ones. It must be emphasized, however, that they are used merely as examples; and that the figures themselves, and perhaps even the deductions from them, though possibly giving an idea of conditions prevailing in this district, cannot be expected to apply in any sense rigorously to estates in other parts of the country. To mention two obvious instances: with the exception of shielding young plants against cut-worm no "pest control" measures are usually necessary on this estate; the cost under section 9 will therefore be much less than where banding, spraying, etc., are essential; *per contra* the expenses incurred under sections 16 and 17 on this estate are, on account of local conditions, likely to be considerably higher than those of estates near Nairobi.

Table III gives the average costs on this estate during the past three years.

TABLE III

	Cost per acre
	Sh. cts.
B.	
6. Cultivation and weeding ..	7 20
7. Couch and headlands	1 00
8. Pruning and handling	1 80
9. Pest control	—
	10 00
C.	
10. Green manuring, etc.	3 10
11. Fertilizing, etc.	17 40
12. Mulching	8 40
13. Irrigation	2 70
	31 60

TABLE III—(*contd.*)

	Cost per ton
	Sh. cts.
D.	
14. Picking, etc.	64 00
15. Factory work	44 00
16. Transport to mill	25 00
17. Bags, milling, etc.	77 00
	210 00
	Cost per annum
E.	£
18. General maintenance	250
19. Management	250
20. Factory, implements, tools ..	100
£	600

As the figures are used principally as examples in the discussions which follow, rather than for any intrinsic significance, no further explanation of their derivation is necessary. Except for the omission of odd cents in order to simplify the arithmetic, they are those obtained in practice without adjustment. Figures for a fourth year have just become available, which substantially confirm the previous results. Further, there is some reason to believe that these costs are normal for the district, and that similar figures are obtained by neighbouring estates of comparable size.

In this table the non-recurrent devlopment items have been omitted, as we are here considering only recurrent production costs.

The cost of the essential B group operations is shown to be Sh. 10 per acre.

The cost of the non-essential C group operations, is not of course of much significance, as the desirability of employing any or all of these treatments, and the acreage over which they are applied annually, will always remain a matter for individual opinion and experiment, and will vary widely from district to district. The effect which the spending of various amounts on these non-essential treatments has on production cost is discussed later. On this estate at the moment the acreage submitted to "special treatments" is quite small, and if the amount spent in this way was averaged out over the *whole* planted acreage the cost per acre would be comparatively slight.

The cost of the essential D group operations, which includes such charges as cost of bags, transport to mill, milling charges and delivery to go-down in Kitale, is Sh. 210 per ton of clean coffee. Coffee from this estate is sold either f.o.r. Kitale or else lying in Nairobi or London. In all cases the appropriate deduction is made from the gross realization to cover subsequent expenses (i.e. insurance, brokerage, railage, freight, etc., which are not usually paid by the planter in cash), and to reduce sale prices to a uniform net condition.

Group E contains all expenditure which cannot be regarded as a direct charge against any particular plantation operation. Section 18 includes such items as rent, insurance, messengers, plantation guards, and maintenance of roads, water supplies, labour lines, and so on; management includes salary and allowances; section 20 includes repairs, depreciation and current replacements in the factory and on all implements and tools. These items will naturally vary in a general way with the size of the estate, but they are obviously not strictly proportional either to the acreage under coffee or to the tonnage of coffee produced. This estate has 200 acres under coffee, and its overhead expenses are about £600 per annum, which is the figure used in the following calculations where a 200 acre estate is being considered. We cannot

claim to have sufficient experience to evaluate precisely what the overheads would be if the estate had 100 or 300 acres of coffee; but in our view it would be reasonable to estimate the overheads of an estate of 100 acres on the same lines at about £100 less, i.e. £500 a year; and for a 300 acre estate under similar conditions at about £100 more, i.e. £700 a year.

Opinions differ widely as to the maximum acreage one European can control. It is maintained here, as the result of personal experience, that 300 acres of coffee is a convenient maximum for one European to manage with reasonable efficiency. It is probable, moreover, that the majority of estates of greater acreage than this are run on company lines, rather than on the owner-manager basis; and as such their organization is likely to be more complex than that considered here, and lies outside the scope of this article.

One item of expenditure which occurs on many estates has been deliberately omitted from consideration here—loan and mortgage interest payments. Such expenditure is not a true cost of production in the general sense, and secondly, as the external indebtedness of different estates varies to such a prodigious extent, the assumption of any particular figure to cover annual interest payments would immediately vitiate the use of the present figures in a large number of cases where they would otherwise be applicable with but slight modification. This omission must however be borne in mind during the following discussion.

The Effect of Various Factors on the Cost of Production of Coffee

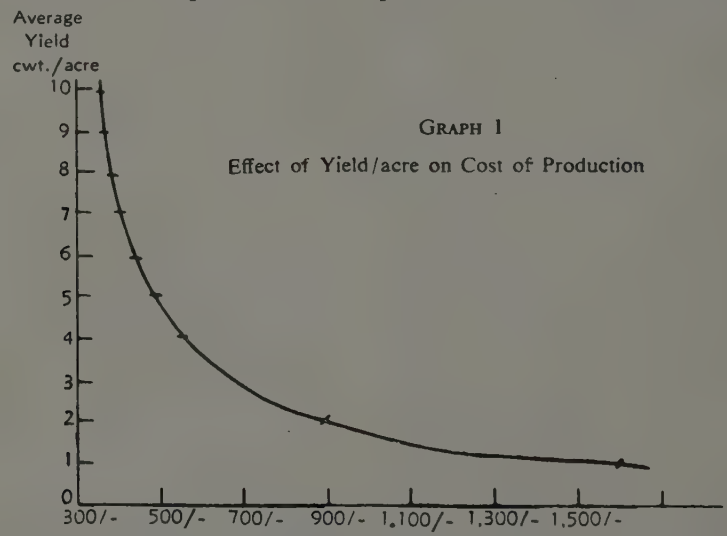
By suitable manipulation of the figures given in Table III one can predict with some certainty the effect that the alteration of various controllable factors will have. Before doing so perhaps one should emphasize once again that the conclusions which follow only apply strictly to an estate (*a*) whose basic cost figures do not differ materially from those given above, (*b*) which produces only coffee, (*c*) which is in full development, and (*d*) which has no external interest payments. The figures may, however, easily be modified to furnish conclusions appropriate to other estates which do not fulfil these conditions, (*a*) by substituting appropriate basic cost figures for those quoted in the examples, (*b*) by charging coffee with only a proportion, instead of the whole, of the overhead expenditure, (*c*) (approximately) by averaging yield per acre over the whole planted acreage of the estate, not merely over the bearing acreage, and (*d*) by adding the interest payments to the other E costs. In order to simplify these substitutions the following tables have been set out in detail, so that any necessary adjustments can easily be made, and an indication is given in algebraic form to show how each column is derived.

A further warning is necessary. In making adjustments the reader must not mistake assumptions for fact. It is obvious that the assumptions made in the following paragraphs are, strictly speaking, relevant only to the actual conditions under which the data were obtained. The relation found in practice between managerial efficiency and acreage managed, between "special treatments" and yield per acre, between "E costs" and acreage of coffee on estates, etc., can be elucidated only by statistical examination of figures for a considerable number of estates or by scientific experiment. The purpose of this article is to show how recorded data may be used by a planter in deducing conclusions applicable to his own case.

A.—The Effect of Yield per Acre on Cost of Production.

The application of a little simple arithmetic to these basic costs will enable a table to be constructed on the following lines to show how yield per acre affects cost of production.

The significance of these results is perhaps easier to assimilate when they are represented as in Graph I.



GRAPH 1

Effect of Yield/acre on Cost of Production

It must be remembered that this graph portrays probably the minimum possible cost of producing coffee under the conditions specified. No allowance has been made for expenditure on special treatments, such as manuring, fertilizing, green manuring, mulching, etc. A plantation treated on these lines would not be likely to give high yields over a period of years. It represents essentially the "low farming" conditions which may be economically sound, or even unavoidable, during periods of low price.

The general shape of the curve supports the fairly widely recognized fact that yields below 3-4 cwt. per acre are not likely to be economic with coffee at its present price. The steepening of the curve as really high yields are attained is worth noting, and the fact that the cost approaches a minimum, for practical purposes, of about Sh. 300 per ton.

B.—Effect of Expenditure on Special Treatments on Cost of Production.

In order to present a more normal picture of affairs, when some effort is being made to keep the estate in good heart by spending a little more than the bare minimum on it, appropriate amounts must be added to the above costs to cover various per acre expenditures on special treatments, such as manuring, etc., which come under the heading C costs.

Taking Table IV as a model we can construct Table V to show the effect on cost of production at various yields of spending an average amount of Sh. 10, Sh. 20 or Sh. 30 per acre per annum, averaged over the whole planted acreage of coffee, on special treatments.

TABLE IV

200 Acres of Bearing Coffee.

B Costs Sh. 10 per Acre.

C Costs Nil (i.e. No Expenditure on Non-essential Treatments).

D Costs Sh. 210 per Ton.

E Costs £600 per Annum.

Yield Cwt. per Acre (*a*)	Acres per Ton (*b*)	Tons per Annum (*c*)	Costs per Ton			
			B. Costs at Sh. 10 per Acre (*d*)	D. Costs at Sh. 210 *f* per Ton (*e*)	E. Costs at £600 per Annum (*f*)	Total (*g*)
			Sh.	*Sh.*	*Sh.*	*Sh.*
1	20	10	200	210	1,200	1,610
2	10	20	100	210	600	910
3	6·66	30	66	210	400	676
4	5	40	50	210	300	560
5	4	50	40	210	240	490
6	3·33	60	33	210	200	443
7	2·86	70	28	210	172	410
8	2·5	80	25	210	150	385
Etc.	etc.	etc.	etc.	etc.	etc.	etc.
Derivation	(20/*a*)	$\frac{200a}{20}$	(10×*b*)	(—)	$\frac{600\times 20}{c}$	(d+e+f)

TABLE V

Yield Cwt. per Ton (*a*)	Acres per Ton (*b*)	Cost per Ton Groups B, D, E (*c*)	C. Costs per Ton			Total Costs per Ton		
			At Sh. 10 per Acre (*d*)	At Sh. 20 per Acre (*e*)	At Sh. 30 per Acre (*f*)	C. At Sh. 10 per Acre (*g*)	C. At Sh. 20 per Acre (*h*)	C. At Sh. 30 per Acre (*k*)
		Sh.	*Sh.*	*Sh.*	*Sh.*	*Sh.*	*Sh.*	*Sh.*
1 ..	20	1,610	200	400	600	1,810	2,010	2,210
2 ..	10	910	100	200	300	1,010	1,110	1,210
3 ..	6·66	676	67	133	200	734	809	876
4 ..	5	560	50	100	150	610	660	710
5 ..	4	490	40	80	120	530	570	610
6 ..	3·33	443	33	67	100	476	517	543
7 ..	2·86	410	29	57	86	439	467	496
8 ..	2·5	385	25	50	75	410	435	460
Etc. Derivation	etc. (20/*a*)	etc. (Table IV column *g*)	etc. (10×*b*)	etc. (20×*b*)	etc. (30×*b*)	etc. (*c*+*d*)	etc. (*c*+*e*)	etc. (*c*+)*f*

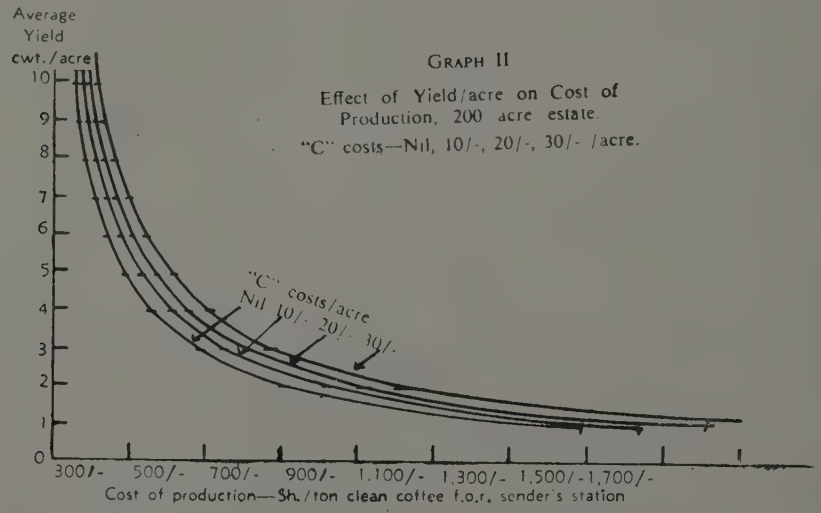
Graph II shows these results pictorially, with the curve from Graph I reproduced to give a basis of comparison.

The effect of the special treatments, over and above what is strictly necessary to maintain the estate as a going concern, may be to improve either yield or quality or both. If suitable increases in quantity are obtained the special treatments can be applied without in any way increasing the cost of production calculated per ton of product. For example, if an extra expenditure of Sh. 20 per acre on special treatments is found to increase yield from 3 to 4 cwt. per acre, the cost of production per ton of coffee remains unaltered. If a greater increase is obtained the cost of production per ton is actually reduced. An improvement in quality will not of course affect the cost of production in any way, but might be expected to improve the average selling price and in this way to increase the profit of the estate.

This shows that cost analyses are necessary to the economic interpretation of experimental results on various coffee cultural treatments.

C.—Effect of Acreage on Cost of Production.

The preceding calculations have all referred to an estate with 200 acres of bearing coffee. For a larger estate the direct costs will remain the same, but the overhead costs per ton of product are likely to be smaller, at any rate until a stage is reached where additional European supervision becomes necessary.



GRAPH II

Effect of Yield/acre on Cost of Production, 200 acre estate.

"C" costs—Nil, 10/-, 20/-, 30/- /acre.

As explained above, it is assumed here that 300 acres of coffee is the upper limit for an estate managed by a single European; further, that the overhead costs on an estate carrying 100 acres of coffee would be £500 a year, and on an estate carrying 300 acres of coffee £700 a year.

Tables can be constructed as before to show the cost of production at various yields per acre for estates of 100, 200 and 300 acres of coffee, managed as one

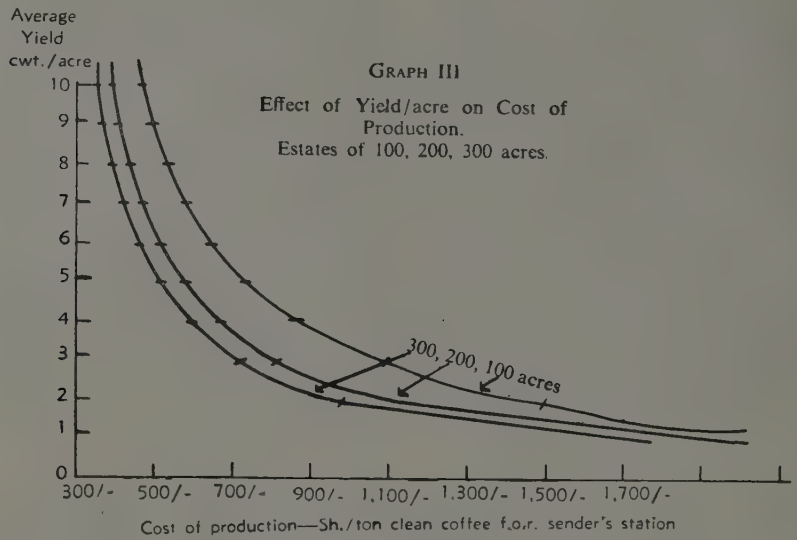
unit. An allowance has been made in each case, and in all the subsequent tables and graphs, of an expenditure of Sh. 20 per acre to cover C costs (special treatments), so that all figures given hereafter represent conditions on an estate which is being kept in good heart by the expenditure of considerably more than the bare minimum amount on cultural treatment. Rather lower costs of production could be obtained on paper by economizing on these C costs, but in practice the probable result would be reduced yields, which would tend more or less to cancel the apparent economy. The addition of this extra C cost also has the effect of making the figures of rather more general application to other parts of the country, where for various reasons B and C costs are likely to be higher than in this district.

It should be noted that the effect, in reducing the cost of production, of adding 100 acres to an estate which already has 100 acres in bearing is considerably greater than the addition of a further 100 acres to the existing 200 acre estate—the usual "diminishing returns" effect.

TABLE VI

Cwt. per Acre (*a*)	Acres per Ton (*b*)	Tons per Annum (*c*)	Costs per Ton: B. Costs At Sh. 10 per Acre (*d*)	C. Costs At Sh. 20 per Acre (*e*)	D. Costs At Sh. 210 per Ton (*f*)	E. Costs At £500 per Annum (*g*)	Total (*h*)
			Sh.	*Sh.*	*Sh.*	*Sh.*	*Sh.*
100-Acre Estate							
1 ..	20	5	200	400	210	2,000	2,810
2 ..	10	10	100	200	210	1,000	1,510
3 ..	6·66	15	67	133	210	670	1,080
Etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
Derivation .	$(20/a)$	$\frac{(100\times a)}{20}$	$(10\times b)$	$(20\times b)$	(—)	$\frac{(500\times 20)}{c}$	$(d+e+f+g)$
200-Acre Estate						At £600 per Annum	
						Sh.	
1 ..	20	10	200	400	210	1,200	2,010
2 ..	10	20	100	200	210	600	1,110
3 ..	6·66	30	67	133	210	400	809
Etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
Derivation .	$(20/a)$	$\frac{(200\times a)}{20}$	$(10\times b)$	$(20\times b)$	(—)	$\frac{(600\times 20)}{c}$	$(d+e+f+g)$
300-Acre Estate						At £700 per Annum	
						Sh.	
1 ..	20	15	200	400	210	930	1,740
2 ..	10	30	100	200	210	470	980
3 ..	6·66	45	67	133	210	312	721
Etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
Derivation .	$(20/a)$	$\frac{(300\times a)}{20}$	$(10\times b)$	$(20\times b)$	(—)	$\frac{(700\times 20)}{c}$	$(d+e+f+g)$

These results are plotted in Graph III.



GRAPH III

Effect of Yield/acre on Cost of Production.
Estates of 100, 200, 300 acres.

The cost of production on a 300 acre estate yielding 5 cwt. per acre is the same as that on a 200 acre estate yielding 6 cwt. per acre. Hence even if allowing one European to manage 300 acres instead of 200 is considered likely to involve a loss of efficiency of as much as 1 cwt. per acre, the cost of production will still remain unaltered. The profit will of course be considerably greater on the larger estate on account of the greater gross production (see below).

THE EFFECT OF VARIOUS FACTORS ON THE PROFIT AND LOSS OF THE ESTATE

Cost of production is only one of the three factors which contribute to the financial success or failure of the estate. Gross receipts = gross yield × average selling price; gross expenses = gross yield × cost of production. The first expression minus the second gives the profit (or loss) of the estate.

The yield per acre, and the acreage in bearing, affect not only the gross yield, but also, as shown above, the cost of production. But in order to avoid constructing a three-dimensional diagram we shall have either to assume an average selling price, and show how profit varies with yield per acre on estates of various sizes, or else assume a yield per acre, and show how profit varies with the average selling price on the same estates. Another possibility is to show the combinations of quality and quantity (i.e. yield per acre and average selling price) required to return a given annual profit.

A.—The Effect of Bearing Acreage and Yield per Acre on Profits.

The preceding tables and graphs give gross output and cost of production for various yield conditions on estates of 100, 200 and 300 acres. Gross output × cost of production = gross expenses. On the receipts side the gross output must be multiplied by the average selling price to give gross receipts. The difference between these two expressions represents profit or loss.

The average selling price assumed here is £40 per ton f.o.r. sender's station. This happens to have been approximately the net realization (after deduction of sales and other expenses not allowed for in calculating the cost of production) obtained by this estate during the past three years. It also corresponds fairly closely with the average sale price in Nairobi for the whole Colony's production as given in the current report of the Coffee Board.

The appropriate figures are set out in Table VII.

TABLE VII

Cwt. per Acre (*a*)	Tons per Year (*b*)	Gross Receipts At £40 per Ton (*c*)	Cost of Production per Ton (*d*)	Gross Expenses (*e*)	Profit + or Loss— (*f*)
		£	*Sh.*	£	£
100-Acre Estate					
1	5	200	2,810	700	—500
2	10	400	1,510	755	—355
3	15	600	1,080	810	—210
4	20	800	860	860	—60
5	25	1,000	730	910	+90
6	30	1,200	642	960	+240
7	35	1,400	580	1,010	+390
8	40	1,600	535	1,070	+530
9	45	1,800	498	1,120	+680
10	50	2,000	470	1,180	+820
Deri-vation	$\frac{(100\times a)}{20}$	$(40\times b)$	(Table VI, col. *h*)	$\frac{(b\times d)}{20}$	(*c*—*e*)
200-Acre Estate					
1	10	400	2,010	1,005	—605
2	20	800	1,110	1,110	—310
3	30	1,200	810	1,210	+10
Etc.	etc.	etc.	etc.	etc.	etc.
Deri-vation	$\frac{(200\times a)}{20}$	$(40\times b)$	(Table VI, col. *h*)	$\frac{(b\times d)}{20}$	(*c*—*e*)
300-Acre Estate					
1	15	600	1,740	1,305	—705
2	30	1,200	980	1,470	—270
3	45	1,800	721	1,620	+180
Etc.	etc.	etc.	etc.	etc.	etc.
Deri-vation	$\frac{(300\times a)}{20}$	$(40\times b)$	(Table VI, col. *h*)	$\frac{(b\times d)}{20}$	(*c*—*e*)

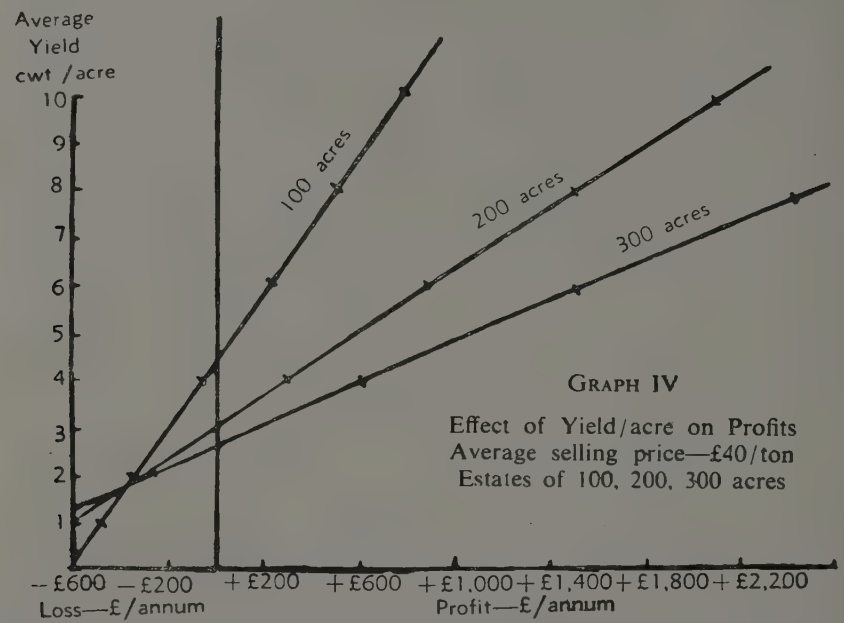
These results are plotted in Graph IV.

The following points are worthy of note:—

(i) In comparing the financial position of estates of 100, 200 and 300 acres it is reasonable to allow for a certain loss of efficiency, shown by a reduction in yield per acre, where one European is solely responsible for the larger acreages. If for the purposes of argument we assume an output of $6\frac{1}{2}$ cwt. per acre to be normal for a 100 acre estate, we ought perhaps to allow a yield of only 6 cwt. per acre for a 200 acre estate, and $5\frac{1}{2}$ cwt. per acre for a 300 acre estate. In spite of a possible loss of efficiency of this nature the profits are greatly in favour of the larger estates, being about £300, £900 and £1,300 in the three classes considered.

(ii) It has already been pointed out that no allowance has been made, in calculating these figures, for any interest payments on borrowed capital. Where external capital is considerable the apparent profit shown in the graph may be to a certain extent swallowed up in interest payments. If, for example, the borrowed capital happened to be at the rate of £20 per acre of bearing coffee, the external indebtedness of the three estates considered above would be £2,000, £4,000 and £6,000 respectively, and the amount of interest due annually at 6 per cent would be £120, £240 and £360. Deducting these amounts from the apparent profits as shown on the graph, we obtain an actual net profit of £180, £660 and £940 per annum for estates which are indebted to a moderate degree.

(iii) There seems to be no possibility of making large profits from 100 acres of bearing coffee, even if tended with such care and skill that really high yields are obtained, so long as the average selling price is in the region of £40 per ton. What are considered (at any rate in this district) as reasonable living expenses for an owner-manager have been



GRAPH IV

Effect of Yield/acre on Profits
Average selling price—£40/ton
Estates of 100, 200, 300 acres

allowed for in the "management" section in calculating the cost of production. But the surplus profits are hardly commensurate with the risks involved, and leave little scope for a high standard of living or an accumulation of reserves.

(iv) Estates of 200 and 300 acres should allow a moderate degree of profit at reasonable yields, and if not too heavily indebted, even at the present level of coffee prices.

(v) The yield per acre at which profit becomes zero is considerably lower in 300 and 200 acre estates than in a 100 acre estate. Yields of only $2\frac{1}{2}$ and 3 cwt. per acre are required in the first two to prevent loss, whereas in the last a yield of at least $4\frac{1}{2}$ cwt. per acre is necessary before any profits whatever accrue. Even with lower yields, down to $1\frac{3}{4}$ cwt. per acre, the larger the estate the less the loss, for any given yield. Below this yield the larger estates show greater losses.

(vi) An increased yield of 1 cwt. per acre shows additional profits of £150, £300 and £450 on estates of 100, 200 and 300 acres respectively.

B.—Effect of Selling Price on Profits.

Having shown above how yield per acre affects profit and loss on the assumption of a fixed price for the coffee, we shall now assume a standard yield of 5 cwt. per acre and show how profit and loss is affected by variations in the average price obtained.

On this assumption we can calculate profit and loss for estates of different acreages on the same lines as before, with the results shown in Table VIII below, and illustrated in Graph V.

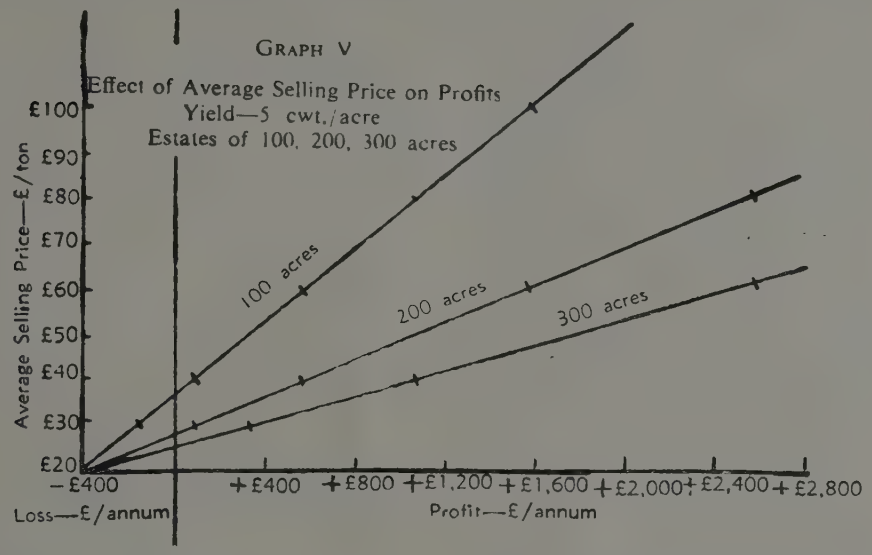


TABLE VIII

100 ACRE ESTATE—OUTPUT 25 TONS AT 5 CWT. PER ACRE

(*a*) Price per Ton	(*b*) Gross Receipts	(*c*) Gross Expenses	(*d*) Profit (+) or Loss(—)
£	£	£	£
20	500	910	—410
30	750	910	—160
40	1,000	910	+ 90
etc.	etc.	etc.	etc.
Derivation	($25 \times a$)	(Table VII col. *e*)	(*b*—*c*)

200 ACRE ESTATE—OUTPUT 50 TONS AT 5 CWT. PER ACRE

(*a*) Price per Ton	(*b*) Gross Receipts	(*c*) Gross Expenses	(*d*) Profit (+) or Loss(—)
£	£	£	£
20	1,000	1,420	—420
30	1,500	1,420	+ 80
40	2,000	1,420	+580
etc.	etc.	etc.	etc.
Derivation	($50 \times a$)	(Table VII col. *e*)	(*b*—*c*)

300 ACRE ESTATE—OUTPUT 75 TONS AT 5 CWT. PER ACRE

(*a*) Price per Ton	(*b*) Gross Receipts	(*c*) Gross Expenses	(*d*) Profit (+) or Loss(—)
£	£	£	£
20	1,500	1,930	—430
30	2,250	1,930	+320
40	3,000	1,930	+1,070
etc.	etc.	etc.	etc.
Derivation	($75 \times a$)	(Table VII col. *e*)	(*b*—*c*)

The following points are worthy of comment:—

(i) Under the conditions of medium yield chosen the larger coffee acreages show quite good profits even at comparatively low prices. To make "good money" out of 100 acres of coffee however necessitates a fairly high average price. For example, to enable £1,000 a year to be realized, a 100 acre estate yielding 5 cwt. per acre needs to average a price of £75 per ton overall, whereas a 300 acre estate at the same yield need only obtain about £39.

(ii) A 100 acre estate must average at least £35 per ton (under the chosen conditions of yield) before any profit at all is realized. The 200 and 300 acre estates need a minimum average of only about £29 and £26 to obtain a profit. Moreover at all price levels above about £20 the larger the estate the less the loss.

(iii) A rise in average selling price of £10 per ton increases profits by £250, £500 and £750 respectively, in the 100, 200 and 300 acres estates, the same effect as would be produced by an increased yield of about $1\frac{3}{4}$ cwt. per acre.

C.—Conditions of Yield per Acre and Average Selling Price Required to Give a Fixed Profit.

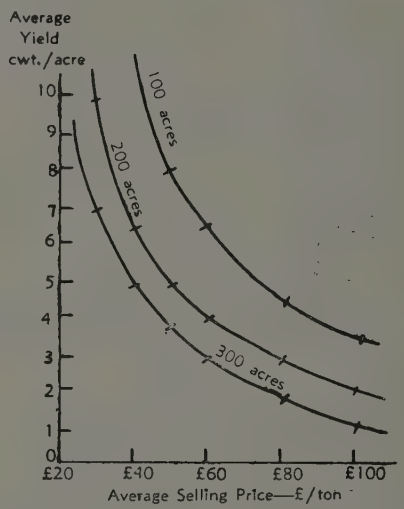
Graph VI shows the limits within which acreages, yields per acre, and average selling price may vary in order to enable a profit of a certain fixed amount to be made—in this case £1,000 a year.

Theoretically this graph shows to what extent a planter who wishes to obtain a certain fixed income from coffee planting can follow his own inclinations in the question of producing quantity versus quality. And if he wishes to concentrate on quantity it shows the relative merits of increasing yield per acre on bearing acreage.

It is hardly necessary to point out that in practice this free choice is largely illusory. A planter may have sufficient good land, energy and finance to enable him to develop a large acreage .But yield per acre depends on a large number of factors, many of which are at present outside his control. And it is hardly an exaggeration to say that, in the present state of our coffee knowledge, the control of quality or selling price is entirely beyond his jurisdiction.

GRAPH VI

Conditions of Yield/acre and Average Selling Price which show profit of £1,000/annum on estates of 100, 200, 300 acres.



A Note on Butter Production and Prices

By V. LIVERSAGE, *B.Sc., M.S. (Wis.), N.D.A., Agricultural Economist, Department of Agriculture, Kenya Colony.*

Fig. 1 illustrates in graphic form the course of prices of butter in London, and of exports from Kenya, from the beginning of 1931. If an attempt is made to steer a middle course through the short-period up-and-down movements it will be seen that the trend of prices was steadily downwards to a low point about the middle of 1934 and thence steadily upward to the present time. The trend of exports is steadily upwards from the middle of 1931.

Both curves exhibit marked short-period fluctuations, fairly regular in prices and irregular in exports. These fluctuations will be seen on examination to be of a seasonal nature.

By appropriate statistical methods it is possible to compute monthly relative indices of prices and production, each figure being expressed as a percentage of normal.[1]

For prices the resulting figures are given in Table I.

TABLE I

Month	Relative Prices
	Per cent
January	93·6
February	94·2
March	92·6
April	94·1
May	94·1
June	99·2
July	101·5
August	106·5
September	111·7
October	111·0
November	104·8
December	94·6

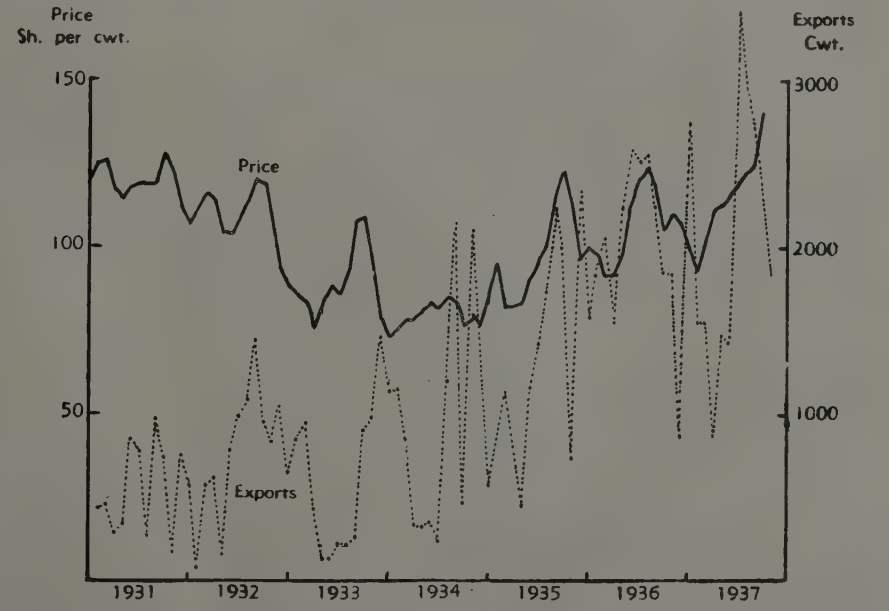


FIG 1.—Monthly Exports of Butter from Kenya compared with Monthly Prices of New Zealand First in London.

[1] The relatives given are averages of the percentages of the trend-line values for the month.

The extreme range is 19.1 per cent, a matter of considerable moment at an average of Sh. 100 or over per cwt.

The question at once arises as to whether these relative prices form a reliable guide or whether they mask a good deal of erratic variation. The answer is that statistical examination proves them decidedly significant.

Statistical Note

The variance between months was 3311 which divided by 11 degrees of freedom gives a mean square of 301.0. The remaining variance was 3282 which divided by 60 degrees of freedom gives a mean square of 54.7. The F value for the comparison is 5.5, whereas the 1 per cent point lies between 2.82 and 2.50. The monthly variation is thus highly significant. The standard error of the monthly average percentage is ± 0.276. Taking twice the standard error (± 0.55) as the limit of significance we notice that the significance of the monthly differences from December to May inclusive is slight or absent, but, as between the period as a whole and the remaining months individually, decidedly significant differences are shown.

The reason for these seasonal differences is not apparent. The volume of imports does not appear to provide an adequate explanation, and data on monthly production within the United Kingdom are not available. Examination of prices of other types of butter may possibly conduce to a better understanding of the factors involved. In the present connexion, however, it is sufficient to note that the monthly differences are statistically significant and can therefore be used as a guide to production policy. It is evident that cold storage in England is not—on the evidence of the past six years—able to iron out the monthly variations. Butter is not sold forward, as are less perishable commodities. Kenya butter is sold on quality as determined by buyers' inspection, and is generally sold shortly after arrival.

How then does the production and export of Kenya butter fit in with the yearly cycle of London prices? The monthly relative quantities exported during the last six years, expressed (as in the case of prices) on a percentage basis, are set out in Table II.

TABLE II

Monthly Relative Quantities of Butter Exported from Kenya

Month	1931	1932	1933	1934	1935	1936	1937	Average
Jan.	—	16	118	159	62	93	77	88
Feb.	—	93	159	99	95	103	76	104
March	—	91	76	37	65	76	46	65
April	—	21	22	35	36	108	76	50
May	149	107	22	37	94	127	—	89
June	139	130	37	25	108	124	—	94
July	51	137	33	130	124	124	—	100
Aug.	190	170	38	235	149	116	—	150
Sept.	138	114	138	53	126	94	—	111
Oct.	34	98	153	217	44	96	—	107
Nov.	125	129	224	151	130	67	—	138
Dec.	92	99	166	53	84	150	—	107

The average monthly relative quantities are shown compared with monthly average relative prices in Fig. 2, in which exports are lagged one month behind prices so as to allow for the period in transit.

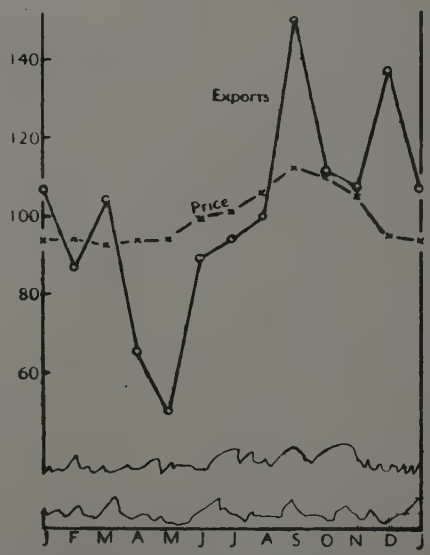


Fig. 2—Seasonal Variation of Prices of Butter on the London Market and of Exports from Kenya. (Exports lagged one month behind prices)

The monthly quantities exhibit wide irregularities. This is due primarily to the vagaries of the seasons, a contributory factor being the accumulation of quantities for shipment in bulk. On the average, it will be seen that the peak of export is in August. These shipments will arrive in time to meet the peak of prices in London in September-October. Then comes a recession before the advent of the short rains, and a secondary peak of export occurs in November, corresponding with the short rains. This short-rains production is normally too late to meet a favourable market in the United Kingdom.

In order to throw further light on the seasonality of exports, the monthly production at two creameries, one, Naivasha, drawing its supplies mainly from the July-August rains area, and the other, Nanyuki, from the April-May and November rains area, is shown in graphic form in Fig. 3. A close examination of this graph will show that at Naivasha the peak of production has generally been about June or July, and the trough in February or March; there has been no regular tendency to a secondary peak in November-December, nor a secondary trough in September-October, though in 1931, 1935 and 1937 these secondary

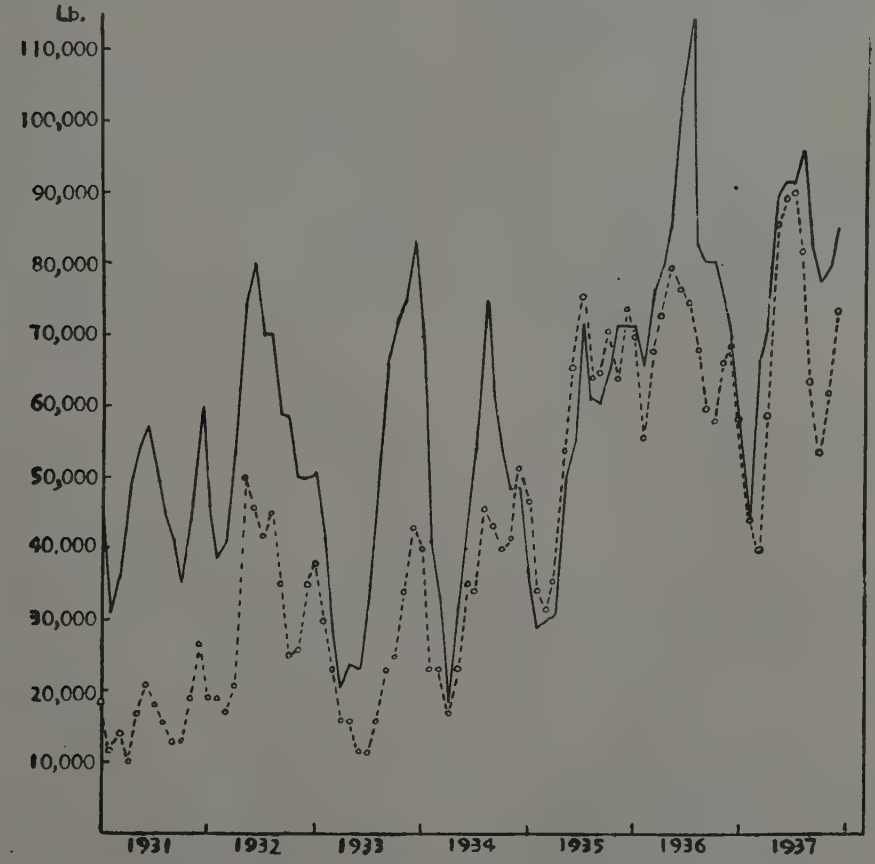


Fig 3.—Monthly Butter Production at Naivasha and Nanyuki Creameries.

movements did occur. At Nanyuki, on the other hand, a long-rains peak about June, followed by a trough about October, and a secondary peak in November-December, is general.

Since it would seem likely that further expansion will be chiefly in the areas west of the Rift Valley, the position may improve as time goes on, and a greater proportion of the total exports reach London in time for the September market.

How far the seasonality of production is due to seasonal calvings is a matter upon which no data are available. The writer's impression is that though this factor undoubtedly plays some part the predominant influence is rainfall. This is supported by the figures in Table II, which show that the yearly cycle is far from uniform.

It seems reasonable, then, to conclude that in the main production coincides fortunately with the seasonal variation of prices on the London market, more so as regards the western than the eastern part of the Colony. On the other hand, particularly as regards the eastern area, a decline in production just before the short rains occurs at a time when London prices are relatively high. Maintenance of high production during this period by fodder crops from long-rains planting is worth careful consideration. Finally, it will be noted that the seasonal range of production is very considerable, exports in the lowest month falling to one-third of the level of the highest month. A large amount of potential production must be lost in the dry seasons, and even if this occurs mainly at a period when London prices are relatively low it must mean a considerable, and probably avoidable, loss of gross income. It may be concluded from the statistics that, though the infusion of improved blood can doubtless be recommended in suitable areas, much improvement is possible with the existing stock. Unless management keeps pace with herd improvement, the value of high-priced imported blood will be largely wasted. It seems hardly an exaggeration to say that with adequate provision of supplementary feeding for the dry seasons exports could be increased by over 30 per cent, even with the existing stock of cattle.

Notes on Two Drug Plants

By T. H. MARSHALL, *Agricultural Officer, Department of Agriculture, Tanganyika Territory.*

I—CALUMBA ROOT

Calumba root is the trade name given to the dried root of *Jateorhiza Columba,* a plant belonging botanically to the moonseed order, Menispermaceae. It is often referred to as Colombo root, because it was formerly thought to be shipped to Europe from Ceylon. It contains, with other alkaloids, a bitter and tonic principle called Columbin.[1] The native name for the plant is *kauma* or *kaomwa* (Sw.).

The plant is a climber, with palmate leaves of eight or more inches in diameter, herbaceous annual stems and large fleshy roots which are produced in clusters. It is found in greatest numbers in the forests of Mozambique, in the Zambesi region, and in the Southern Province of Tanganyika. It has also been reported as growing in other parts of the East African coast and as far south as Natal.

The roots, which are obtained from wild plants, are used in native medicine as a stomachic and as a remedy for dysentery, and in European medicine as a bitter tonic. The roots are dug up in dry weather and the numerous off-sets from the base are separated, cut into transverse slices and dried. The old root is rejected. The dried product appears on the market in circular or oval biconcave sections of from one to two inches in diameter and from one-tenth to half an inch in thickness.

Exports of the dried roots were made from Tanganyika Territory before and just after the War, but until quite recently no further shipments have been made. Prices have undergone great fluctuations. Before 1914 the price was about Sh. 15 per cwt.; during the War it rose to Sh. 90, and in 1919 to over Sh. 400, owing to scarcity of supplies in European markets. With the cessation of hostilities, huge quantities were poured into Europe, causing prices to slump so heavily that eventually large stocks were either destroyed or sold at prices as low as Sh. 1/50 per cwt. At that time commercial experts stated that sufficient supplies were still available in England to meet the demand for the next ten years or more, and this is no doubt the reason why business houses have taken little or no interest in the crop until recently. With more interest being shown, production has again started and shipments are being made.

II—STROPHANTHUS EMINII

The seeds of species of the genus *Strophanthus* are used in medicine for cardiac affections, the seeds containing digitaloid glucosides. Almost the whole of the world's present supply is collected from wild plants of *Strophanthus kombe* in Nyasaland, where some years ago legislation controlled the exploitation of the plants, the collection of the seeds being done under licence and a royalty paid before they could be sold. This royalty was abolished in 1914, and the legislation

[1] According to Flückiger and Hanbury (*Pharmacographia,* London, 1874), *Radix calumbae,* "Calumba, Columbo or Colombo" root, was then already known to be "held in high esteem by the natives of East Africa, who call it *Kalumb.*" Evidently, then, *Kauma* and *Calumba* represent the same word. The root was admitted to the London Pharmacopœia in 1788 and Columbin was discovered in 1830.—*Editor.*

which controlled the industry lapsed in 1926.

The genus *Strophanthus* belongs to the natural order Apocynaceae. Over forty different species are known to occur in Africa, including Tanganyika, but the only one so far commercially exploited to any extent, and at present official in the British Pharmacopœia, is *Strophanthus kombe*. The drug, strophanthin, is also obtained from the seeds of *Strophanthus hispidus*.

There is another species, *Strophanthus Eminii*, that grows profusely in Tanganyika, with medicinal properties similar to the two species referred to above. It is known to the natives as *msungululu, mweri-weri, mhunguti, mtondo* or *mtowe*, and is widely distributed from Iringa right through the Central Plateau to Mwanza, particularly in the Kahama, Singida and adjoining districts. The plant is a bush of from ten to thirty feet in height, and is found in dry places. It has violet-coloured flowers so strongly scented when they are out the countryside smells strongly as of heliotrope. The pods containing the seeds are spindle-shaped and woody and are borne in wide-angled pairs. The pods are from ten to eighteen inches in length, are brownish-grey and rough on the outside. The seeds are covered with lustrous yellow hairs with a naked awn one inch or more in length, with a tuft of hairs of similar length at the end of the awn. These hairs are very hygroscopic and contract and expand in dry or wet weather, and, when the seeds are released from the pod, these hairs form a kind of parachute. The fleshy roots are used in native medicine, and are dug, sliced, then beaten in a wooden mortar and an infusion made in cold water. This is afterwards warmed and used as a specific against skin irritations; it is a tribal custom to wash newly born babies in the infusion.

In 1928 the Imperial Institute started an investigation of the properties of the species of *Strophanthus* indigenous to Tanganyika, from seeds collected from plants identified by the Royal Botanic Gardens, Kew, as being those of *Strophanthus Eminii* Asch. & Pax. As a result of this examination, the Director of the Pharmacological Laboratory of the Pharmaceutical Society of Great Britain has recorded that for medicinal purposes the seeds of *Strophanthus Eminii* are indistinguishable from those of *Strophanthus kombe*. In view of this, the British Pharmacopœia Commission was approached to include the seeds of *Strophanthus Eminii* in the latest edition of the Pharmacopœia, which at the time was under revision; but by then it had not been possible to collect a sufficient body of experimental data to justify this. It is understood, however, that the matter is still under consideration. A report on the work done on the seeds has been published in the *Journal of Pharmacy and Pharmacology* (Vol. VIII, No. 1, 1935). An account by I. D. Lamb and S. Smith of the strophanthin of *Strophanthus Eminii* seeds appears in the same publication.

In 1929 the laboratories of the Rockefeller Institute for Medical Research, New York, expressed a desire to investigate for comparative purposes the essential chemistry of the seeds of *Strophanthus Eminii*, and seeds were supplied from the Kahama District. The Rockefeller Institute has published an account of its investigations into the properties of the seeds in the *Journal of Biological Chemistry* (Vol. XCIX, No. 2, 1933).

It is understood by the Imperial Institute that the quantity of *Strophanthus* seed sold to meet the requirements of the British Pharmacopœia is only a small proportion of the entire trade, and there

may be a market in other directions. A London firm who do on extensive trade in *Strophanthus* seed, both in England and on the Continent, has expressed the opinion that if seed of *Strophanthus Eminii* can be offered at a suitable price, there should be no difficulty in finding a market. Accordingly, a trial consignment of 5 cwt. was sent; a profitable return was realized, and has resulted in a demand for commercial shipments.

The supply of the seed is purely seasonal, the main season for collection being August to September. Harvesting must be done shortly before the pods ripen, because if the pods are left until they are mature they burst; the light seed loosens itself very easily from the smooth inside of the pod, and with the long tuft of hairs attached is easily blown away by the slightest breeze.

Preparation for the market is simple. The seed is removed from the pod and the hairs from the seed, which is then well dried. It has been emphasized that it is desirable to ship the seed with a green colour, but this does not appear to be feasible with *Strophanthus Eminii.*

The Successful Selection of Seed Maize

By HUGH C. COLTART, *Njoro, Kenya Colony.*

The successful selection of seed maize requires "an infinite capacity for taking pains" and it has been proved beyond doubt that the pains taken amply repay one. This was clearly demonstrated at the last Nairobi Show by that excellent exhibit staged by the Department of Agriculture, when the difference in crop from properly selected seed and poorly selected seed gave Sh. 50 an acre in favour of good seed. These figures are from actual tests of seed grown on the same soil in the Seed Maize Competition.

The maize farmer is indebted to Mr. G. J. L. Burton for the theory of maize seed selection and every farmer would be well advised to read his Bulletin No. 2 of 1930 every year before selecting his seed maize. A few practical hints, however, after many years of following this theory, may be useful to growers.

Selection can be made from the growing plant but, as Mr. Maher has pointed out, the maize cob is unfortunate in not knowing its own father; therefore there is no benefit to be gained from this tedious process. Selection can be made from the crib when shelling, but as shelling is a rapid process many good cobs pass through the sheller. The most practical method is to select cobs when taking the maize from the stook. This can be done by an intelligent native when the ordinary labourer has finished the stook, and if the selected cobs are placed together side by side, the farmer can rapidly discard any cobs not up to standard.

Select the long and heavy cobs with regular grain—the grain should be thick and translucent and of the flint or smooth type. Avoid the dent or spike type of grain. The flint type of translucent grain will be found to give a much higher percentage of disease-free cobs. The excessively long cob should be avoided as this tends to produce exposed tips.

The selected cobs from the stook are carted to one end of the maize crib, or preferably to a separate store where there is no possibility of mixing with the main maize crop. The store or crib should have three divisions on the floor.

This can be done by using maize stalks or in the field with tarpaulins.

Cutting the cob is an important point in seed selection. Cut about 2 inches off the tip with a sharp *panga* (bush knife) and the exposed pith core, which varies in colour from pure white to almost black, shows whether the cob is clean or diseased.

The cutting can be done by trained boys who are taught to place:—

Pure white cored cobs in division No. 1.

Impure white cored cobs in division No. 2.

Pink or brown or black cored cobs in division No. 3.

Before the cut cob is placed in its correct division the large misshapen seeds on the butt are knocked off with the blunt side of the *panga* (except, of course, for No. 3 Division).

No. 1 division is the seed maize.

No. 2 division is to be used as seed maize if No. 1 is insufficient.

No. 3 division is useless for seed and is shelled with the ordinary maize crop.

This preliminary division has been found to be quicker than making a final examination of each cob.

Now is the important part for the farmer and on the principle that "if you want a thing done well do it yourself", he must devote most of his time to going carefully over the No. 1 cobs, as many of them will be degraded to No. 2. A very good light is necessary for examining the pith core of the cob and a great variety of "white" cores will be found. The hard snow-white core is the real No. 1 and the marble-white should be relegated to No. 2. The farmer will also carefully examine No. 2 division and any cores showing a tinge of pink or brown should be transferred to No. 3 One point worthy of mention: all this should be done after an early night!

A puzzle to many farmers in selecting is that many cobs have a snow-white pith with a dark red surround, but some have an equally good white pith with a yellow or brown surround. Some selectors think the latter a sign of disease, but it is merely varietal, and this type of cob is equally good for seed.

Examination and grading of cobs should be completed as soon as possible after the tips have been removed, as the pith is apt to dry rapidly and become discoloured, thus giving a false impression of the quality of the cob.

To summarize:—

(1) Select cobs from the stook.

(2) Follow the three divisions for the cut cobs and one cannot go far wrong.

(3) Select only the *snow-white* cores for the Seed Maize Competition and one will soon gain first place.

One other aid to seed selection: if possible plant a small area of the best seed away from the main group, where it cannot be cross fertilized from poor plants, vigorously rogue out any weak or malformed plants in this area, subject to lodge, etc., and thus assure the seed having a fairly respectable parentage.

This sounds a long and involved process, but in reality is simple and, as stated at the outset, the time and trouble involved are well repaid—in fact they make the difference between success and dismal failure in maize growing. With the help of the plant breeders, mycologists, and more intelligent seed selection, maize yields have increased beyond belief.

Reconditioning of Coffee Pulpers

By A. W. BARNLEY, *Kiriga Estate, Thika, Kenya Colony.*

The ordinary type of coffee pulper is subject to unavoidable wear of the drum covering and the breast, and as soon as the wear of either becomes considerable faulty pulping results. A new copper cover, applied as accurately as possible to the drum, puts that into good condition again, but until the breast has been restored to its initial state of accuracy or a new one is fitted, the pulper is still a menace to the coffee it treats.

The actual heavy casting of the breast becomes distorted after a time, as can be easily seen if a "straight edge" be laid along the inside of the casting. Only a slight distortion makes it impossible to adjust the breast so that it will perform its work properly. In addition to this fault the breast wears in the form of grooves running downwards from the "throats". A breast in this condition is scrapped as a rule, and there are many hundreds of them lying about on plantations. A very large percentage of these breasts are capable of having two or three more lives given to them.

The writer has successfully tried a method of renovating the breast, which enables it to do at least three times the work hitherto expected of it. This method, which seems not to be generally known, was explained to him by a well-known Kenya coffee planter, who makes a practice of it. It consists in having the breast "turned out" in a lathe by removing only a small depth of the metal, and this "trueing-up" can be repeated when necessary at least twice, and in some cases three times. The cost is under Sh. 40.

The knives, whether new or old, should be left in situ during the turning operation.

The grooves worn into the working surfaces of the doors will have to be ground out in such a way that the working face is parallel to the axis of the drum. If these grooves are too deep for grinding out, new doors must be fitted. The doors are made of chilled iron, and the chill (hard skin) does not penetrate very far into the metal. If the grinding is carried too deep the doors will groove again very quickly, as a great deal of the work of pulping is concentrated on them.

An Indigenous System of Soil Protection

By B. J. HARTLEY, *M.B.E., N,D.A., A.I.C.T.A., Agricultural Officer, Department of Agriculture, Tanganyika Territory.*

The Erok people of Mbulu District inhabit the mountainous country which rises between the Great Rift Valley and the Yaida and Eyassi depressions. The origin of the tribe is obscure, but Leakey[1] has suggested that they may be the descendants of neolithic people of the type inhabiting the City of Engaruka, whence Masai history records the Mbulu District tribes fled. Whatever their origin, these people have an intelligence which appears to be above the type shown by the ordinary Bantu peoples.

Under pressure from the Masai on their nothern flank and with treacherous neighbours in the Tatoga peoples, the timid Erok were, for some time before the advent of the European, confined to a limited area which they had carved out of the forest clad mountains. Like other tribes in similar circumstances, such as the Wamatengo and Wakara, they evolved a system of soil conservation.

The slopes under cultivation would deter almost any but those who find it necessary to eke out a living there, but a favourable rainfall and a not infertile soil compensate for the considerable labour required to a farm on the Erok system.

Land for cultivation is whenever possible selected in the steep and narrow valleys. The fields are of small size, generally about one quarter of an acre and are made to occupy a single "terrace". These terraces are in the early stages protected by a storm drain above the field and cultivation is designed to work the soil away from the slope until it is level. Owing to the steepness of the slopes and the adjustment of a field to each terrace, the vertical interval between the terrace edges is considerable; for this reason a perfectly level terrace is only seen in favourable situations. The climate provides an all-the-year-round growing season and enables the cultivator to protect his terrace edges with grass and crops; as a result the usual deterioration of the terrace edge so commonly seen in drier situations does not occur.

The formation of a terrace is a gradual process. After the construction of a storm drain, followed by the pulling down of soil from a face say three feet deep, and the provision of a Kikuyu grass verge on the edge of the terrace, cultivation will proceed.

Old fallow land or new land is deeply cultivated with a long digging pole which turns over the sod, leaving a very deep broken surface to weather in the cold season. With the advent of the true short rains season and higher temperatures this land will be contour planted between small ridges with (say) maize, while a strip of pumpkins is established on the lower side of the "terrace" to afford additional protection. At hoeing time the ridges are commonly reinforced according to the season and the amount of rubbish which may have been buried. In some cases the ridges may be split back to earth-up crops, but still naturally retain their soil and water conserving principle.

Important practices affecting the terraces occur when the next planting takes place. Assuming that a short rains crop

[1] Leakey, S. B.: *Kenya, Land of Contrasts and Problems*

has been removed in May, the cultivator's next work is to chop out the stover and lay it evenly over the field. The value of this thatch in conserving moisture is understood by the Erok cultivator, who could well do with such stover as forage for cattle from his overstocked grazing. When cultivation takes place this stover is drawn into lines starting at the lower side of the terrace, then ridged over and the seed planted at once between the ridges; in the process of ridging the soil is pulled downhill and gradually season by season the terrace is formed.

To those experienced in the dangers of even green manuring under dry conditions it seems remarkable that a heavy stand of dry stover can be so disposed of after the heavy rains without any noticeable effect on the following crop. Too often trash and weed growth is burned or eaten off in the field owing to difficulties of disposal in the soil; this Erok method of sowing a listed crop between the ridges carrying rotting crop residues is a development which would well repay investigation elsewhere under varying conditions of rainfall.

Soil movement within the plot under this system is reduced to a minimum while at the same time loss from the terrace is adequately controlled. Wash from land surrounding the cultivated terrace is, in the old Erok country, of little danger on account of the presence of a fair grass cover, while depth of soil assists in the formation of the terraces, many of which have faces twelve feet deep.

The problem which now confronts Government is the introduction of anti-soil erosion measures to the members of the tribe who have moved from their ancestral fields to the drier, less mountainous areas. Here, overstocking, flat cultivation and rainfall more of the unstable type found in semi-arid areas, provide ideal conditions for wide-scale soil damge. The Erok, no longer afraid, is content to cultivate and move on; he has become a miner instead of a farmer.

Reviews

Lucerne in South Africa[1]

By R. S. BALL, *B.A., Dip. Agric. (Cantab.), A.I.C.T.A., Agricultural Officer, Department of Agriculture, Kenya Colony.*

A useful and comprehensive pamphlet on the above subject has recently been published by the Department of Agriculture in South Africa and much of the information contained therein is likely to be of considerable value to East African farmers. A summary of some of the more important features relating to the cultivation and management of the crop is therefore appended.

The expansion of the acreage of Lucerne under cultivation has gone to a large extent hand in hand with the extension of irrigation facilities, since there are no other crops which will yield such a high return per acre of protein-rich feeding stuffs under these conditions.

Lucerne is characterized by its deep root system, which at an early age assumes a tap root form, superseded later by a more or less branched habit. Root development takes place throughout the life of the plant, roots 10-20 feet long being common and lengths up to 50 feet having been recorded. The importance of a deep soil is therefore obvious if maximum root development is to take place. The plant, like other Leguminosae, of which family it is a member, forms root nodules (made by nitrogen fixing bacteria) which are small and not readily seen unless the plants are dug up with great care. Although Lucerne can grow without these nodules, they are essential for really satisfactory growth.

There is a much inter-varietal variation in number of stems per plant, ratio of leaf to stem, thickness of stem, but these characters will also be affected by climatic and cultural factors, such as moisture and time of cutting. The leaves provide the greatest feeding value of the plant and therefore the importance of preserving them needs no emphasis. There is, however, a slight varietal difference in proportion of leaf to stem, slightly higher in Provence than in Hunter River. Also the first and last cuts of the season appear to have a higher percentage of leaf than the intermediate ones, which tend to flower more readily. It would appear that this is likely to hold good in Kenya if irrigation is not practised, the dry season intervening as a dead season.

The plant will flourish under a fairly wide range of conditions, except where high temperatures and high humidity are correlated; these conditions are detrimental owing to the incidence of disease and very heavy weed growth. Lucerne prefers alkaline to acid soils, the latter being frequently found in areas of high rainfall. Old lucerne plants will withstand a fair amount of alkali in the soil, but young plants are not so tolerant and hence it is difficult to establish the crop on alkaline lands. It is not uncommon to find that the deeper and less acid soils most suited for the cultivation of the crop are in dry areas, where irrigation is necessary for its successful growth. Under irrigation lucerne is vigorous in growth, will withstand rather unfavourable soil conditions, and is not much affected by soil type provided the soil is

[1] Turpin, H. W., and others, 1936: "Lucerne in South Africa," Bulletin No. 190, Department of Agriculture and Forestry, Union of South Africa.

deep, well drained and fertile. Where there is adequate moisture, highest yields are only obtained on deep uniform well drained soils preferably containing lime, although the presence of lime is second only in importance to a fairly well drained soil. The stand and yield of the plant will be speedily reduced by water-logging of the soil and good drainage is essential. If underground water in the soil is supplying all the needs of the crop, once the roots have penetrated to the water table a sudden rise may adversely affect yields.

For successful results with lucerne the following points need attention:—

(1) Good physical condition of soil.
(2) Manurial requirements.
(3) Preparation of seed beds.
(4) Use of water.
(5) Time of harvesting.
(6) Curing hay.
(7) Grazing.
(8) Varieties.
(9) Inoculation.
(10) Perfect stand.
(11) Weed control and cultivation.

Since the plant is a long-lived perennial legume, it is not normally considered suitable for inclusion in a crop rotation. Where virgin land is to be devoted to the crop, it is desirable that for at least one season an annual, e.g. oats, should be grown, which will help to destroy unwanted vegetation and ensure a good physical condition in the soil.

Where lucerne requires to be replanted owing to reduced yields, weeds, etc., it is desirable to allow several seasons to elapse before it is replanted, in order to clean the land and allow the restoration of its moisture. A considerable depletion of soil moisture takes place with such a deep rooted crop and it may prove difficult to re-establish lucerne immediately for this reason, while crops such as maize and potatoes will benefit from the nitrogen stored in the land.

Inoculation of the soil may be necessary in order to produce the nitrifying bacteria essential for a high protein content of the plant and healthy growth. These bacteria are frequently already present, except on sour soils. The presence of any form of bur clover, trefoil or medick indigenous on the farm indicates that the soil is already supplied with the bacteria. American opinion favours the transference of soil for inoculation purposes although this inoculation can be effected by manuring the land with the dung of animals fed on lucerne hay or by the use of artificial cultures of the material with which the seed is treated.

Fertilizers

In South Africa it has been found beneficial to apply cattle manure to the previous crop, to allow of weed destruction before planting the lucerne, and that dressings of superphosphate every third to fourth year, prior and subsequent to planting, give increased yields. Owing to the wide range of conditions under which lucerne is grown, it is impossible to generalize about the use of manures; in some cases these have produced no effect whatsoever and therefore it is difficult to translate South African results to East African conditions. Experiments in East Africa have shown that a complete dressing of mineral fertilizers may be beneficial, but the experiments are at present in their initial stages and no conclusions can be drawn definitely. Probably under the best soil conditions, as at Lake Naivasha, fertilizers may have no effect, as in rich alluvial soils in South Africa.

Preparations for Sowing

Where lucerne is grown under irrigation, various methods of distributing the

water on the crop are used, but in South Africa the system of border flooding has proved very successful. This consists of diverting water on to specially prepared beds, which may be 10, 20, 30 or more feet wide, depending on circumstances, and allowing the water to find its own course down a gentle slope, at the same time being confined to definite beds by means of retaining walls or ridges. This system is expensive at the outset but cheap in working costs as it enables one man to handle a large amount of water. The essential is to level the land so that the distribution of water shall be even and uniform.

Sowing

Under such irrigation the crop is usually hand sown either with a broadcaster or seed barrow, but this is not always desirable in East Africa where drilling in rows is necessary in order to permit of cultivation and weeding. Under ideal conditions, however, with irrigation, where the plant makes very strong and healthy growth, broadcasting is possible.

Choice of Seed, Seed Rate and Sowing

It is essential to use first class seed guaranteed free from dodder. The seed if kept dry will retain its germinating capacity till after the fourth year. The rate of seeding used is very variable, averaging about 16 lb. per acre, but ranging downwards to much lower rates under very favourable conditions. Although under certain conditions in South Africa the use of a nurse crop is recommended, experience in this country has tended to show that this is undesirable owing to the fact that it checks growth and tends to make the plants spindly.

The seed should be sown to a depth of $\frac{1}{2}$ in. to 1 in. on well prepared land, and in order that the young crop should root deeply it should not be irrigated more than is essential. Rolling with a Cambridge roller is recommended on the lighter soil types, but not if the land is likely to pack.

Dry Land Lucerne

Where the crop is dependent on rainfall only, cuttings are fewer than under irrigation and are dependent on the rainfall. Diseases are usually more prevalent, there is greater weed competition and planting in wide rows is recommended to permit of inter-cultivation. Yields are frequently lowered after three years owing to the depletion of moisture in the soil, and if it is intended to replant such land, it should undergo a crop rotation before it is re-seeded with lucerne.

Treatment of Young Lucerne

Growth of annual weeds may be vigorous in young lucerne despite the fact that the land was well cleared prior to planting. Such weeds should be mowed with the mower set high, so as to cut as little of the young lucerne plants as possible. The material so cut need not be removed unless it is so thick that there is a danger of smothering the lucerne. Apart from control of annual weeds, young lucerne should only be cut off when the plants are well in bloom, by which time numerous young shoots at the base wil have formed. Grazing of young lucerne also should be avoided. Two to three cuttings during the maiden year is the most that can reasonably be expected from young lucerne.

It is not advisable to attempt to thicken up old stands or poor stands of lucerne by re-seeding. It is better to plough out and replant.

Cultivation of the Mature Crop

As lucerne ages, it tends to become more and more weedy, owing to depletion of soil fertility, gradual loss of vigour if grazed, cutting at the incorrect

stage, etc., with the result that cultivation is often considered a necessity. The evidence in regard to the efficacy of cultivation is, however, conflicting. Where lucerne is making normal growth, there is probably little benefit to be derived from cultivation, but where weeds and grass threaten it, its life may be prolonged by thorough cultivation. Various types of implements are used for cultivation, e.g. an ordinary disc harrow, a springtooth harrow or Martin cultivator or a Killifer cultivator. Some authorities state that a disc or any implement likely to split the crowns is injurious and that a modified form of springtooth harrow is the most suitable. On heavier soils, however, this type of implement will be ineffective and it is necessary to use a cultivator or an implement with greater power of penetration. An irrigation prior to cultivation may greatly assist in the penetration of the implement.

The incursion of weeds is at all times troublesome and is much increased if cattle are grazed on the crop. Effective weed control is necessary in order to prolong its life. A troublesome parasitic weed found in South Africa is Dodder. Great care should be exercised in using clean seed, and infected patches in the field should be burnt.

Haymaking

The greater part of the crop is normally cut for hay, and the aim of the farmer should be the production of a clean, fine-stemmed, leafy, sweet and green-coloured hay.

As much as 20 per cent and even more of the leaf may be lost in the process of curing, thus seriously affecting the quality of the hay. Little difference in total yield results from cutting lucerne from the 10 per cent flowering stage onwards, but the quality is definitely affected. More leaf tends to be lost from lucerne cut in the older than in the younger stages, while there is a material increase in the fibre content of the stalks. Taking all these factors into account it would appear desirable to cut lucerne at the 10 per cent flowering stage, so as to combine both quality and quantity. American workers consider, however, that early cutting ends to shorten the life of the plant and favours weed growth, and this has been corroborated by South African results.

Mowing

Mowing should not be commenced until the dew is off the plant, but in the absence of dew, mowing should take place as early as possible to allow of the cut lucerne drying during a single day and being ready for raking the following morning. This will tend to reduce the loss of leaf that will occur where the hay is allowed to lie in the swath for a long period. Lucerne should be raked in the cooler hours as much leaf is likely to be lost if raked during the heat of the day. While it is possible to make excellent lucerne hay in South Africa by careful handling and drying in the field, more care is required in this country, where shade drying or the use of tripods is frequently or usually necessary. The effect of rain on the value of lucerne hay has been clearly demonstrated by American workers, who estimate that the loss of nutrients following a rain of 1.76 inches spread over fifteen days amounted to 31.7 per cent of the total nutrients and 60 per cent of the available protein. If rain falls immediately after cutting it is best to leave the lucerne in the swath, where it will dry quicker and the only portion to suffer damage will be the exposed surface, which will become severely bleached. The fitness of lucerne hay for stacking may be judged by:—

(*a*) Whether it exudes moisture or not when a wisp is twisted vigorously.

(*b*) When the skin on the stems cannot readily be scratched off with the finger nail.

(*c*) When a handful of the hay is held against the cheek, cooïness of the hay indicates a high moisture content.

(*d*) If a handful of the hay held loosely rattles when shaken, it is an indication of dryness and fitness for stacking.

Hay which has heated or sweated in the stack, although sometimes slightly more palatable, has a lower feeding value than green hay.

Baling in the field instead of stacking requires great care; there is more risk that moulds will develop in the bale than in the stack, so the hay should be drier than if stacked. Direct baling usually results in a saving of leaf and a better coloured hay. Hoop steel is recommended for baling instead of wire, so as to avoid the danger of animals picking up pieces of wire in the hay.

Utilization of Lucerne

The maximum crude protein content of commercial lucerne hay recorded in South Africa is 20 per cent, and the lowest 13.69 per cent, with an average of 16 per cent, these figures clearly indicating its value as a feed. Further, its nutritive ratio averages 1 : 3.9. Furthermore it can be used as hay, pasture, soiling or a silage crop, while under favourable conditions it has considerable value as a seed crop. It is also marketed as a meal for use largely as a poultry feed. The meal is said to be more digestible than the hay and wastage in feeding is avoided.

The crop is frequently grazed in spite of the risk of hoven, and the danger of affecting the stand. Grazing in excess or too frequently is very injurious to the crop. Strict rotation of grazing appears essential in order to avoid this damage. It is seldom desirable to use lucerne as the sole grazing crop, but stock should be alternated between this and ordinary grass. If, however, sheep are kept continuously on lucerne it appears that the danger of hoven is practically eliminated.

When used as grazing for dairy cows, large variations were found in milk production; the composition of the lucerne varied on successive days of grazing and it was found necessary to supplement with other foods. Furthermore, taints frequently developed in the milk of animals grazed on lucerne, and cows had to be removed from lucerne three hours before milking in order to eliminate these taints.

Bloat of Hoven

Lucerne has the disadvantage of causing bloat in ruminants when it is grazed or fed green, thereby rendering its use in this manner risky. Lucerne which is wilted, or highly succulent, is extremely dangerous.

Hot dry winds, which cause the rapid wilting of young luscious lucerne, are conducive to hoven. To minimize danger from bloating, farmers follow different systems, such as day and night grazing, gradual lengthening of the grazing period and the provision of permanent water and dry feed in the fields. If lucerne has attained the 100 per cent flowering stage, the danger of bloat is reduced. Bloat appears to be associated mainly with the water content of the plant, stage of growth, type of soil and hot winds, all of which influence wilting, a very important factor in bloat. Certain animals are predisposed to bloat either on account of greediness or inherent weakness. A drench of raw linseed oil one pint and turpentine 1 oz. is an excellent remedy for cattle. For sheep an ounce

of bicarbonate of soda followed by a little water is effective, but little difficulty has been experienced with sheep when allowed to graze continuously on lucerne, probably owing to regular dosings with wire worm remedy.

Lucerne Silage

Owing to its high protein content care must be exercised in ensiling lucerne. It has been found satisfactory to add 1½ per cent of commercial molasses by weight and dilute with water (3 or 4 parts water to 1 part molasses) to allow of more even distribution. The lucerne should be chaffed for ensilage, and it is essential that the material should remain cool, else a loss in protein will result. Imperfectly packed material is likely to heat and the silo should be filled as quickly as possible. The plant should be cut at the first flower stage and not allowed to become too mature. The silage should be ready for use in four to six weeks. Lucerne silage should be supplemented with hay to secure the best results in feeding.

Seed Production

Where there is abundant soil moisture, lucerne grows rapidly and few seed pods are set; the crop seeds only when vegetative growth is severely retarded. Harvesting is usually carried out when about two-thirds of the seed pods have turned dark brown. The crop may be treated subsequently like a hay crop, but care must be taken in handling so as to avoid loss of seed by shedding. In the U.S.A. it is customary to use a mower with reaping attachment or, where the crop is tall, a reaper and binder. Threshing is usually performed with a clover huller or an ordinary small grain thresher fitted with special sieves. Lucerne is usually not allowed to produce seed until it is two years old. Farmers state that the production of seed improves the subsequent hay crop, owing to the resting effect. Yields of seed are very variable, but average about 300-400 lb. per acre.

Cost of Production

This will vary greatly according to whether the crop is grown with irrigation or not. The usual cost under irrigation in South Africa lies between £1/10/0 and £2/10/0 per ton of hay produced; and it is probable that these figures are approximately correct for East Africa, when the lower labour costs, but higher handling charges such as shade drying, are taken into account.

Disease

Lucerne is assailed by several diseases in South Africa. Leaf Spot is probably the most important to East African farmers, since it is present wherever lucerne is grown in East Africa. It is caused by a fungus (*Pseudopeziza medicaginis*) and the severity of the attack is much influenced by weather. It takes the form of a leaf spotting which spreads from the lower leaves upwards. When it becomes unduly evident, it is advisable to mow or graze the crop in order to avoid as much loss from defoliation as possible. By the time that the next cutting has developed it is likely that the weather will have changed and a comparatively healthy cutting will be obtained, except in damp hot areas where the disease is extremely prevalent and widespread.

Other diseases of interest mentioned are rust (*Uromyces striatus*), the control measures for which are similar to those of leaf spot, and also Crown Rot, the control measures for which are rotation of crops, drainage, and improvement of cultural conditions.

LUCERNE AS A FOOD FOR HUMAN CONSUMPTION[1]

The occurrence of scurvy amongst the native labourers of the industrial population of the Transvaal led in 1920 to the investigation of experimental scurvy by Dr. E. M. Delf. Since then the chemical constitution of the vitamin concerned—Vitamin C—has been determined and, in addition to its identification as the single chemical entity known as ascorbic acid, methods for its rapid estimation have been evolved. It is now possible to measure the amount present in a particular foodstuff more accurately and rapidly than was possible by the earlier method of animal experimentation.

The present report is concerned with the application of these more modern methods to the same problem, and deals with one particular foodstuff—lucerne (*Medicago sativa*). A brief historical survey traces its progress from its native regions of Western Asia through Greece, Italy and the North African oases until its arrival in Spain during the Moorish invasion, whence it has spread throughout the world.

In South Africa it is grown in considerable quantities, but its suitability for human consumption has been questioned on the grounds of alleged toxicity. The work of Steyn has, however, traced death following its use as a forage crop to the presence in it of poisonous weeds or to the effects of excessive fermentation following its consumption in large amounts. Further investigation has revealed that in spite of this its use as a human food has been practised in various parts of the world and in South Africa itself.

Chemical analyses are quoted from various sources referring to both energy-yielding and mineral constituents of lucerne, and reference is made to published work on its contents of the individual vitamins. On the Vitamin C content, with which the investigators were particularly concerned, no earlier work was known and its distribution in the plant at three stages of development was examined. At the stage described as young lucerne and at the flowering stage, the amount per gram of lucerne varied from 2.2 to 3.8 mg. of ascorbic acid, and a table is given showing that this is an outstandingly high figure when compared on the same basis with the contents of a variety of South African fruits and vegetables. Different varieties of lucerne showed varying but consistently high values.

The process of cooking may lead to an almost complete destruction of Vitamin C, and the authors have studied the losses that may occur, with a view to reducing them to a minimum. They advocate the use of leaves and young shoots only, and as soon as possible after their removal from the coarse stalks. They may be added directly to a salad or substituted for parsley in soups and stews.

In these ways a substance which contains appreciable quantities of protein, especially in its earlier stages, which is rich in minerals and especially in calcium and iron, and which is an outstanding source of Vitamin C, may with safety be incorporated in the dietary when the occurrence of scurvy is a possibility. It has the further advantage that many of its properties are retained when it is dried,

[1] Fox, F. W., and Wilson, Cicely: "Lucerne as a Food for Human Consumption," Laboratory Report No. 3 of an Inquiry into Native Diets, South African Institute for Medical Research.

and it is a hardy plant lasting for several years on the same ground and standing extremes of heat and cold.

The report concludes with two appendices, the first giving brief notes on the cultivation of the plant and referring to its climatic, soil and fertilizer requirements, while the second gives suggestions for using it as part of the ration of mine labourers. For the latter, the material should be cut before the flowering stage and at as short a time as possible before use, washed and chopped. This treatment should be followed by mincing, which reduces it to a fine state of division, and it should be added to the stew only a short time before issue so that it shall have been in contact with the boiling liquid for no more than a few minutes.

D. H.

THE PRACTICAL ASPECTS OF COPRA DETERIORATION

The manufacture of good copra is not a difficult business. It demands good nuts and care throughout the duration of the drying process which should be carried on without interruption from the time the nuts are broken until the copra is completely dry. Most of the defects in copra arise through immaturity in the nuts or delays in the drying process.

A recent publication by F. C. Cooke[1] deals comprehensively with the subject of "quality" in copra, with the characteristics and causes of copra deterioration, with the prevention of deterioration, and, finally, with copra grading in the field and the laboratory. The publication contains an important list of references to recent work on copra, and should be of great value to those whose work is concerned with improved copra production.

In dealing with the subject of copra quality the author points out the necessity for defining the factors which comprise "good copra" and "bad copra" and follows this with a series of descriptions of copra qualities ranging from Perfect copra to Low-grade copra, together with a statement of the physical characteristics of each.

The section of the report dealing with marketing and the conclusions at the end of Part I are of considerable importance to East African producers and especially to those of Zanzibar, where the industry has just emerged from the stage at which "wet" copra, not dry copra, was the standard product. The author points out that in Malaya, when "wet" copra is the standard product, local buyers cover themselves against loss of quality or of actual weight by discounts on the price or on the weight of the purchased product, and thereafter bulk the copra purchased from numerous producers until it becomes self dried by its own heat of decomposition. This system was also followed in Zanzibar, but has changed as a result of improvements in the quality of copra, and differential prices are now being paid for different qualities.

As has been the case in the Far East, the increased quantity of high-grade copra available in Zanzibar has resulted in an increased local demand for high-grade copra by the local oil mills, with the result that the best copra in Zanzibar is not available for export. As the author points out, this condition of affairs will persist so long as the London market remains disinterested in high-grade copra and is unwilling to prescribe standards.

[1] Cooke, F. C., 1937: "The Practical Aspects of Copra Deterioration," General Series No. 28, Department of Agriculture, Straits Settlements and Federated Malay States.

Part II of the Bulletin, which deals with copra deterioration, merits careful study by producers in East Africa. The characteristics of deterioration are stated at length and the agents of deterioration in Malaya listed. The characteristics of deteriorated copra which are mentioned are to be found all too frequently in East Africa.

The profound effects of moisture, both external and contained, in facilitating deterioration through the action of moulds and bacteria are of particular interest to those whose work lies with the small producer in East Africa, where the most frequent cause of deteriorated copra lies in delay in starting to dry nuts after splitting them and failure to carry the drying process to completion.

The objection to oversmoking of copra, another common fault in East Africa where much copra is still prepared on a crude platform over a smoky fire of coconut husk, lies in the sharp flavour and bad colour imparted to the oil. Overheating, on the other hand, may leave copra which is superficially scorched, internally scorched or burnt black, and may result in a loss of oil and copra.

In dealing with the prevention of deterioration, a tabulated summary of the avoidable causes is presented under the heads of: careless harvesting, careless pre-treatment, careless manufacture, faulty kilns, careless storage and transport; and the unavoidable causes under the subheads of prolonged storage of superior copra and imperfect "meat" development in nuts.

For the prevention of deterioration the author recommends the careful drainage of the split nuts, accompanied by washing with water or with a weak solution of sodium carbonate, and the employment of sun-drying for some hours prior to loading on the kiln. Delays in starting the drying process are fatal if good quality copra is to be obtained. The kilns should be warm when loaded, and overloading and consequent deterioration in a moisture-laden atmosphere avoided. The author advocates improvements in preparation as the only lasting contribution to the solution of damage by moulds and insects in prepared copra.

The final part of the Bulletin deals with grading in the laboratory and the field, and also with commercial grading. In relation to the latter, the author points to the weakness in the system whereby the copra of a country is sold as f.m.s. or f.m. by a process of averaging-up the purchase of various qualities, and, consequently, to the lack of encouragement to producers to attempt to turn out copra above the country's general standards.

In the publication it is pointed out that there are at present approximately forty recognized grades or qualities of copra, none of which are clearly defined, and the suggestion is made that any form of national grading should be in the direction of simplification. In this connexion the last paragraph of the publication is worth quoting *in extenso*:—

> "At the present time, copra of f.m.s. grade from the Straits is not of the same quality as copra of f.m.s. grade from the South Seas. It would seem to be to the mutual benefit of all coconut-producing countries if copra could be marketed on a common basis so that each grade would be, as far as possible, of the same relative physical quality whatever the source. It would then be simple to value standard-grade copra from various countries exactly according to the known, standard, or estimated oil content."

J. C. M.

A FORESTER'S NOTES FROM "THE TSETSE FLIES OF EAST AFRICA"[1]

Editor's Note.—Mr. Swynnerton's work has received notice before in this Journal; but it is of such many-sided importance that no apology is needed for further reference to it.

Mr. Swynnerton describes how tsetse flies have in the past saved great areas of Africa from destruction by erosion caused by shifting cultivation and cattle. He then states:—

> "The flies have, in effect, been occupying and guarding the country until man should grow wise in his use of it . . . ; it is our duty to-day not to reclaim these tracts unless, having reclaimed them, we regulate the methods of agriculture to be applied to them, and limit the numbers of cattle that should exist in them, in such a way as to ensure that the country shall not deteriorate."

These words might well have been printed in large red type on the cover of his volume. Further on Mr. Swynnerton adds:—

> "But, in reclaiming new country, we must plan for all this from the start. It will be too late when the land is destroyed as the result of hand-to-mouth settlement methods. I do not think that we have in the past shown fully our fitness to reclaim; but I do think I see the cloud, as yet no bigger than a man's hand, that indicates that the pleas of the apostles of anti-erosion are at last producing an impression . . ."

The 579 pages of this monumental work are packed with information about the distribution, habits and ecology of nine East African species of tsetse, their habitats and their relations to them. Various methods of attack and defence, direct and indirect, by the breeding and release of parasites, by trapping, by clearing, by isolation of special vegetational areas, by discriminative clearing, by burning, by protection from burning, by planting, by the production of barriers of open country or dense thicket, and by removal and regulation of game, are discussed in detail. Experiments and experimental techniques are fully described, and a complete history of the work, organization and staff of the Tsetse Research Department of Tanganyika is given.

The most important discovery of this Department is that each species of tsetse needs a concurrence of different types of vegetation for its feeding, resting and breeding grounds, and if it is deprived of this, either by degrading or advancing one of the types, the species must go. Thus, for instance, *Glossina morsitans*, which needs shady savanna for resting and breeding and relatively open glades or plains near by for hunting, will disappear when the savanna is converted into either open grassland or dense bush. This sounds fairly simple, but other species of tsetse that like the changed conditions may appear in increased numbers.

The problem of each tsetse-infested area must be studied individually and a combination of methods employed. In the case quoted above, if the savanna is thickened sufficiently to make it unsuitable for *G. morsitans*, trapping and indiscriminate clearing will probably have to be undertaken as well to deal with *G. pallidipes*.

The value of air survey in planning anti-tsetse work has been demonstrated by experiments, and such surveys will

[1] By C. F. M. Swynnerton: *Transactions of the Royal Entomological Society*, London, Vol. 84, 1936.

also provide maps on which to base anti-erosion prophylaxis, regulation of settlement and provision of permanent water in the reclaimed areas.

Mr. Swynnerton stresses that complete clearing and destruction of vegetation is not only dangerous for the soil but very expensive. He advocates the minimum of destruction, by the use of barrier clearings between large areas of certain types of vegetation, which can only be infested when they are in contact with other types, and these other types. Wherever improvement of vegetation by protection from fire or by early burning will assist in the removal of tsetse he considers these methods should be used, often in conjunction with discriminative clearings. He writes:—

> "The object of all our discriminative clearing, it may be repeated, is to clear as little as is necessary of one vegetation type only in those spots only which are essential to the fly at one season only of the year."

In connexion with this work there are a section and an appendix dealing with the technique of tree poisoning, a subject of great interest to foresters. Mr. Swynnerton found arsenic pentoxide introduced by the frill method to be the most effective way of killing savanna species, but states that concentrations as high as 10 lb. to the gallon of water were necessary with some of the species. A concentration of 4 lb. to the gallon tried on a number of rain-forest species was ineffective. Sodium arsenite is stated to have been even less successful. It is possible that Mr. Swynnerton wanted more rapid results than are required by foresters, when poisoning rain-forest species to help young established regeneration. Experiments in Uganda, based on the now proved technique of the Malayan Forest Service, show that a concentration of sodium arsenite as low as ½ lb. to the gallon of water is likely to be effective within a few months against local rain-forest species.

Planting is expensive and is only a practical proposition as discriminative planting to fill gaps in barrier thickets, etc., that cannot be filled by natural thickening consequent on fire protection. This might not be so if the work could be made remunerative by the establishment of economic species, but so far no success has been obtained with such species under the conditions of the various experiments. This is not surprising, since the gaps to be filled are often hard-pan strips.

As in all artificial establishment for indirect benefits, it is essential for the avoidance of nursery, transport and transplanting expenses to have species that will grow freely at stake, either from seed or from cuttings. So far, success has been obtained with Ceara rubber (*Manihot glaziovii*) and *Euphorbia tirucalli* from seed and cuttings respectively. All the Eucalypts tried, which included *E. crebra, siderophloia, amygdalina* and *rostrata,* besides less likely ones, were exterminated by termites. *Cupressus* failed, and, rather surprisingly, *Callitris* also, while *Cassia siamea* and *Thuya orientalis* have had some success. Various indigenous species, including many thorny climbers, were tried, and of these *Harrisonia abyssinica* was the best. A species that is not listed but appears to the writer to be worthy of trial in Uganda is *Zizyphus mauritiana.*

The book contains detailed description of a number of vegetational communities, such as Miombo (*Isoberlinia-Brachystegia*-other genera), Nyika or Thornbush (*Acacia-Commiphora-Ostryoderris*-other genera), and its numerous subdivisions, *Commiphora schimperi-Lannea humilis,* and of the forest and thicket types of various islands in Lake Victoria.

The following is a list, drawn up from Part 2 of the book, of the nine species of tsetse found in East Africa, with their economic importance and vegetational requirements. The letters (K), (T), (U), refer to the presence of the species in Kenya, Tanganyika and Uganda respectively:—

(*a*) *Glossina morsitans* Westwood (T), (U).—A carrier of nagana to cattle and of Rhodesian sleeping sickness to man. Requires savanna of sufficient shade for resting and breeding and relatively open glades or plain for breeding.

(*b*) *Glossina swynnertoni* Austen (K), (T) (not Uganda, though parts of Karamoja would appear to be suitable).—A carrier of nagana to cattle and of Rhodesian sleeping sickness to man. Requires dry and open areas for feeding, breeds in thickets or rocks; resting haunts (of females at least) in broken thickets.

(*c*) *Glossina pallidipes* Austen (K), (T), (U).—A carrier of nagana to cattle and potentially of Rhodesian sleeping sickness, but not a ready feeder on man. Requires open spaces for feeding and thickets for resting and breeding.

(*d*) *Glossina austenii* Newstead (K), (T).—Relation to cattle uncertain, but attacks readily and is considered to be a carrier of nagana in Jubaland. Very rarely attacks man. Bases itself on dense or fairly dense thicket as its breeding and resting haunt and sallies out to feed in country devoid of undergrowth or with open spaces interspersed.

(*e*) *Glossina palpalis* Rob., Desv. (K), (T), (U).—Of little importance to cattle but a carrier of the *gambiense* type of sleeping sickness to man. Requires open savanna for feeding and thickets for resting and breeding.

(*f*) *Glossina brevipalpis* Newstead (K), (T), (U).—A carrier of nagana to cattle and a potential carrier of Rhodesian sleeping sickness to man, but attacks man less readily than most tsetse do. Requires tree savanna for feeding and heavy thicket for resting and breeding.

(*g*) *Glossina fuscipleuris* Austen (K), (T), (U).—May transmit disease to both cattle and man, but this is not yet definitely known. Requires plains or open savanna for feeding and dense thickets for resting and breeding.

(*h*) *Glossina fusca* (Walker) (U).—A species of very limited areas and therefore of little economic importance. Requires dense rain-forest for resting and breeding, and feeds along paths and game tracks.

(*i*) *Glossina longipennis* Corti (K), (T), (U). A semi-desert species frequenting the drier types of thorn bush. Appears to avoid water. Nothing more is known of it.

Appendix 10 of the volume contains a field key to both the adult flies and the pupæ of the East African species.

N. V. B.

Correspondence

RAMIE

Sir,

Recently I received an article published in the *East African Agricultural Journal* (November issue), dealing with ramie, containing statements with which I do not agree.

It has been my ambition to make this a British product which will take its place in the world market as cotton has. I have devoted over twenty years to the study of this subject from every angle, and I am more than convinced that this can be accomplished, and sooner or later this fibre, due to the qualities which have been known from remote times, will come into its own. Ramie was known as the linen of the Bible, and was also extensively used for windings of mummies, due to its powerful resistance to atmospheric and other reactions.

For a number of years endeavours have been made by various people to promote companies to exploit this fibre, with little knowledge beyond the fact that they could remove some of the gum (which is very adhesive) or, alternatively, all the gum, by a secret chemical process which destroyed its true value.

Another difficulty which must be borne in mind is suitable machinery for the preparing and spinning. To my knowledge there is only one firm who can do this, namely Messrs. Greenwood & Batley of Leeds.

In 1919 it occurred to me to use what is known as rejections of ramie for the purpose of making medicinal cottonwool. I accordingly made a quantity and submitted same to the Red Cross, and in November, 1919, I received their report that comparative tests had been made with the best qualities of cottonwool, with the following results:—

"Sterilization showed no change in the absorbability, and very little in the consistency of the fabric, and less tendency to pack as in the case of absorbent cotton. Pads made and applied directly to freely draining wounds show—

(*a*) wounds clean and dry when pads removed;

(*b*) pads evenly saturated with discharge.

"Pads evenly saturated with discharge compare favourably with absorbent cotton pads of the same weight, holding the discharge rather better than cotton with less tendency to soiling of bedding through penetration of the pad. Used pads show less tendency to pack and become unevenly wadded than similar cotton pads. Ease of application and adaptability equal to cotton. Testimony of patients indicates equal comfort. No evidence of any injurious chemical reaction."

In 1931 I was informed by Dr. Goulding, of the Imperial Institute, that ramie could be grown freely in East Africa, and at one time endeavours were made to find a market for undecorticated ramie ribbons at £11 per ton. I then realized that this could be used for medicinal cottonwool. I got in touch with Major Dale, the Commissioner of H.M. East African Dependencies, through whom I received 60 lb. of undecorticated ramie ribbons in April, 1936, and I reported on this on the 18th September, stating that it was not suitable for the textile industry, but could be made into cottonwool, which I did and named it "Silkleen," and have submitted same to the Voluntary Hospitals Association. I received the following report from Mr. S. Dunston, the House

Governor and Secretary of the Royal Victoria Infirmary, Newcastle-upon-Tyne, who carried out these tests on behalf of the Voluntary Hospitals Association:—

"Newcastle-upon-Tyne, 3rd July, 1936.—I thank you for your letter of the 17th ultimo, and for sample of 'Silkleen.' We have thoroughly tested this, sterilizing it, etc., and are of the opinion that it compares equally in every way with cottonwool."

A previous report from Mr. Dunston on "Silkleen" made from imported ramie from China is as follows:—

"30th September, 1935.—'Silkleen' is a line that is worth developing, and should prove a sound commercial product."

On the 13th December, 1935, he writes as follows:—

"I can only repeat when I said before that we find this wool is quite comparable with cottonwool in every way, and when you are in a position to offer same in half-ton lots (wrapped in 1 lb. packets) I should be pleased if you would let me know."

I have also made various tests with ramie for the textile industry, and have received the following reports:—

From Messrs. Greenwood & Batley, Leeds:—

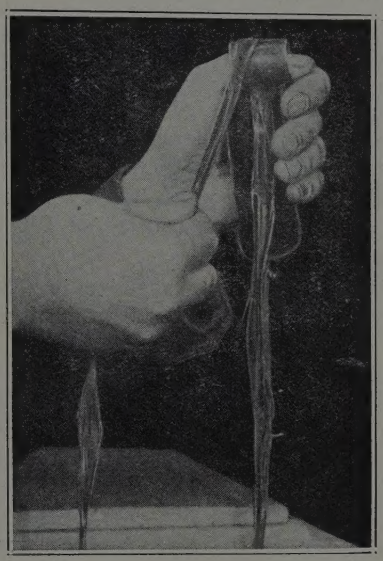
"We may say at once that the yarn produced from your degummed filasse is of very excellent quality, the colour, sheen and evenness being much above the average. In fact, our spinner friends have expressed to us the opinion that your degummed fillasse is superior to their own, and they exhibited great curiosity as to the manner in which the degumming process has been done."

From the Edison Swan Electric Co.:—

"In reference to our conversation with you on the telephone in reference to the sample of yarn sent us for test, we beg to advise you that this was found to be satisfactory and the price about 2/6 per lb."

The above reports clearly show the possibilities of ramie apart from other industries that use wadding, or cottonwool, by the ton lots, such as the upholstery, and various forms of packing, where the quality need not be as good as for medicinal purposes.

I have made further experiments with machinery for preparing the fibre for spinning, and can now produce a clean sliver and an even yarn with a considerable saving in the cost of production.



The ramie now imported from China is only used for specific purposes, and not in any of the above-mentioned industries. In fact, the yarn is too expensive to be used extensively. Further, I do not agree with the difficulties stated in the Journal article in dealing with the decortication, and from the description the method used was incorrect.

The average production of the Chinese natives is about 3 lb. of hand-cleaned

fibre per hour. (I have actually been in the fields and watched them.) A piece of thin round metal is held in the palm of the hand, another piece of thin metal is made in the shape of a ring to fit on the thumb, reinforced with a piece of rubber inside. The thumb with the ring is pressed against the edge of the metal held in the palm, and the fibre is drawn through, thus removing the pellicle, and at the same time the gum is squeezed out.

I have in mind several ways of how this method could be improved, and there should be no difficulty for the natives in East Africa to produce 30 to 40 lb. a day of hand-cleaned ramie ribbons.

Last month I received about 20 lb. of clean ramie ribbons from the Director of Agriculture, Kenya, which were beautifully cleaned, and the colour was very good. I understand it came from Songhor district, and in my opinion it was superior to the Chinese product. There should be no difficulty in realizing about £30 per ton for it.

In 1936 a friend of mine in China investigated the costs and production of hand-cleaned ramie, and reported that the difference for decorticated ramie ribbons was so small that it was not worth while exporting undecorticated. I gave copies of this correspondence to Major Dale.

However, I thoroughly agree that the best plan, and probably the only one for the time being, is to have a plant on the plantation to produce ramie fillasse for exportation, and in fact I have advocated this for some time. I propose to do this myself as soon as I complete my investigations, provided I can get the necessary assistance to establish a plant in a suitable district in Kenya.

Information which I have from the Agricultural Department of Kenya shows that labour and land are practically as cheap as in China, and I see no reason why the cultivation should not prove a profitable proposition.

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